U.S. Army Corps of Engineers
Omaha District

2003 Annual Report for the Omaha District's Water Quality Management Program

A Compilation of Information Pursuant to the U.S. Army Corps of Engineers' Engineer Regulation No. 1110-2-8154

March 2004

(Page left intentionally blank)

2003 Annual Report
for the
Omaha District's Water Quality Management Program

A Compilation of Information Pursuant to the U.S. Army Corps of Engineers' Engineer Regulation No. 1110-2-8154

Prepared by:

Water Quality Unit
Water Control and Water Quality Section
Hydrologic Engineering Branch
Engineering Division
Omaha District
U.S. Army Corps of Engineers

March 2004

This document is approved for release:

Dave Jensen 23 Mar 2004

Dave Jensen – Team Leader, Water Quality Unit **Date**

Chris Horihan 23 MAR 2004

Chris Horihan – Acting Chief, Water Control and Water Quality Section **Date**

For Information Regarding This Document Please Contact:

Dave Jensen
U.S. Army Corps of Engineers, Omaha District
Attention: CENWO-ED-HA
106 South 15th Street
Omaha, Nebraska 68102-1619
(402) 221-4622
david.e.jensen@usace.army.mil

TABLE OF CONTENTS

Page

PREFACE

The U.S. Army Corps of Engineers (Corps) Engineer Regulation No. ER 1110-2-8154, "Water Quality and Environmental Management for Corps Civil Works Projects" (USACE, 1995), requires that an annual report be prepared that summaries the District's water quality management program and highlights specific project information and activities for the past fiscal year. The report is to describe:

- The goals and objectives of the water quality management program.
- Progress made toward meeting water quality management goals.
- Activities that are planned for out years.
- Changes in technical capabilities.
- Relationships between water quality and water control management activities.
- Pertinent regulations.
- Laboratory facilities.
- Data management systems.
- Training needs.
- Research and development needs.
- Special studies completed or required.
- Water quality coordination with other agencies.
- Scheduling for detailed project evaluations.
- Problems encountered with contracted work.
- Identification of hindrances to meeting goals and objectives and proposed solutions for their removal.
- Special assistance from:
  - Committee on Water Quality.
  - Water Operations Technology Support Program.
  - Corps Laboratories.
  - HQUSACE.
- Other information as requested by HQUSACE.
- Project-by-project summaries that address:
  - Water quality conditions.
  - Problems encountered and how addressed.
  - Opportunities identified and how addressed.
  - Innovative techniques utilized to improve water quality.
  - Special regulation activities.
  - New or modified data collection programs.
  - Plans to address identified problems.
  - Possible Corps-wide application of available data (e.g., R&D).
  - Ongoing applied research.
  - Changes to project water quality objectives.
  - Regulation/operation modifications for water quality.
  - Modifications to sampling programs and objectives.

Much of the information identified in ER 1110-2-8154 for inclusion in the annual report is available for 2003 in other existing documents prepared by the Omaha District in support of District's water quality management program. These documents include:

- "Strategic Plan and Guidance for Implementing the Omaha District's Water Quality Management Program", (USACE, 2003a).
- "2003 Program Management Plan for the Omaha District's Water Quality Management Program", (USACE, 2003b).
- "Framework for Monitoring Water Quality at the Missouri River Mainstem Reservoir Projects in the Omaha District", (USACE, 2003c).
- "Sampling and Analysis Plan for 2003 Monitoring of Omaha District Reservoirs in Nebraska", (USACE, 2003d).
- "Sampling and Analysis Plan for 2003 Monitoring of the Missouri River in Nebraska", (USACE, 2003e).
- "Sampling and Analysis Plan for 2003 Monitoring of Omaha District USACE Tributary Reservoirs in North and South Dakota", (USACE, 2003f).
- "Sampling and Analysis Plan for 2003 Ambient Monitoring of the Missouri River Mainstem Reservoirs", (USACE, 2003g).
- "Sampling and Analysis Plan for 2003 Lake Sakakawea Intensive Survey", (USACE, 2003h).

In preparing this report to meet the annual reporting requirements identified in ER 1110-2-8154, the District's overall goal was succinctness. Where possible "bullet listing" and tables are provided. If more detailed discussion is desired on a particular item, it may be available in the above documents.

(Page left intentionally blank)

1 GOALS AND PURPOSES OF THE WATER QUALITY MANAGEMENT PROGRAM

The Strategic Plan and Guidance for Implementing the Omaha District's Water Quality Management Program (USACE-OD, 2003) identifies the following goals and long-term objectives to direct implementation of the District's water quality management program.

GOAL 1: Ensure that water quality, as affected by District projects and their operation, is suitable for project purposes, existing water uses, and public health and safety and is in compliance with applicable Federal and state water quality standards.

Long-Term Objectives for Implementing Goal 1:

1) Determine if any surface water quality concerns exist that are due to the operation of District projects.
2) Where degraded surface water quality conditions exist at District projects, develop a plan for restoration that will restore water quality and the aquatic environment to a desirable, biologically diverse, productive, and robust condition.
3) Evaluate District projects and their operations to ascertain that they offer the lowest possible stress to surface water quality and the aquatic environment.

GOAL 2: Establish and maintain a water quality monitoring and data evaluation program that facilitates the achievement of water quality management objectives, allows for the characterization of water quality conditions, and defines the influence of District projects on water quality.

Long-Term Objectives for Implementing Goal 2:

1) Characterize surface water quality conditions at District projects.
2) Quantify any surface water quality concerns identified at District projects.
3) Provide data to support reservoir regulation elements at Districts projects for effective management and enhancement of surface water quality and the aquatic environment.
4) Evaluate the effectiveness of structural or operational measures implemented at District projects to enhance surface water quality and/or the aquatic environment.

GOAL 3: Establish and maintain strong working partnerships and collaboration with appropriate entities within and outside the Corps regarding water quality management at District projects.

Long-Term Objectives for Implementing Goal 3:

1) Provide technical support on surface water quality issues to other Corps echelons.
2) Maintain coordination and communication among Corps elements involved in water quality management matters.
3) Maintain close coordination and, where possible, collaboration with all interested governmental and nongovernmental entities with an interest in water quality conditions at or affected by District projects.
4) Use a team approach to develop objectives, establish priorities, and execute the District's Water Quality Management Program.
5) As appropriate, promote and develop cost-sharing partnerships in accordance with available authorities.

GOAL 4: Document the water quality management activities of the District's Water Quality Management Program and projects to record trends, identify problems and accomplishments, and provide guidance to program and project managers.

Long-Term Objectives for Implementing Goal 4:

1) Apply the Corps Program Management Business Process (PMBP) to the implementation of the District's Water Quality Management Program.
2) Prepare an annual report of water quality conditions in the Omaha District.
3) Prepare an annual report on the implementation of the District's Water Quality Management Program.

The Strategic Plan and Guidance for Implementing the Omaha District's Water Quality Management Program (USACE-OD, 2003) identifies the following purposes and 16 monitoring objectives to direct implementation of the District's water quality data collection activities.

PURPOSE 1: Determine surface water quality conditions at Corps projects.

Monitoring Objectives for Implementing Purpose 1:

1) For all new Corps water resource projects, establish baseline water quality conditions as soon as possible and appropriate.
2) Characterize the spatial and temporal distribution of water quality conditions at Corps projects.
3) Determine if water quality conditions attributed to the operation of Corps projects are improving, degrading, or staying the same over time.

PURPOSE 2: Determine if any surface water quality concerns exist that are due to the operation of Corps projects.

Monitoring Objectives for Implementing Purpose 2:

4) Determine if water quality conditions at Corps projects or attributable to the operation of Corps projects (i.e., downstream conditions resulting from reservoir discharges) meets applicable Federal, state, and tribal water quality standards.
5) Assess water quality conditions at Corps projects in relation to potential sources, transport, fate, and effects of contaminants.
6) Evaluate water/sediment interactions and their effects on overall water quality at Corps projects.
7) Identify the presence and concentrations of contaminants in indicator and human-consumed fish species at Corps projects.
8) Investigate, as necessary, unique events (e.g., fish kills, hazardous waste spills, operational emergencies, health emergencies, public complaints, etc.) at Corps projects that may have degraded water quality or indicate that the aquatic environment has been impacted.
9) Identify pollutants and their sources that are affecting water quality and the aquatic environment at Corps projects.

PURPOSE 3: Quantify any surface water quality concerns identified at Corps projects.

Monitoring Objectives for Implementing Purpose 3:

10) For identified surface water quality concerns at Corps projects, determine the loading capacity for contributing pollutants.

11) For identified contributing pollutants at Corps projects, estimate the current watershed loadings for those pollutants.
12) Identify critical areas within project watersheds that are contributing nonpoint source pollutants that are a concern.
13) Calibrate and validate water quality and watershed models used to assess water quality concerns at Corps projects.

PURPOSE 4: Provide data to support reservoir regulation elements at Corps projects for effective management and enhancement of surface water quality and the aquatic environment.

14) Provide water quality data required for real-time regulation of Corps projects.
15) Collect the information needed to design, engineer, and implement measures or modifications at Corps projects to enhance surface water quality and the aquatic environment.

PURPOSE 5: Evaluate the effectiveness of structural or operational measures implemented at Corps projects to enhance surface water quality and/or the aquatic environment.

16) Evaluate the effectiveness of implemented measures at Corps projects to improve water quality and the aquatic environment.

2 PROGRESS MADE TOWARD MEETING WATER QUALITY MANAGEMENT GOALS

The 2003 Program Management Plan for the Omaha District's Water Quality Management Program (USACE-OD, 2003) contains an Action Plan for implementing the District's Water quality Management Program during the period April 2003 through March 2004. The report "Implementation of the 2003 Program Management Plan for the Omaha District's Water Quality Management Program – To Be Developed", (USACE-OD, 2004) will contain a final assessment on the implementation of the identified action items. Table 1 provides an interim progress report on the action items identified in the 2003 Program Management Plan for the District's Water Quality Management Program.

TABLE. 1. Progress in Implementing the Action Plan detailed in the 2003 Program Management Plan for the District's Water Quality Management Program.

Action Items	Tasks	Target Dates	Progress
WATER QUALITY MONITORING AND ASSESSMENT ACTIONS			
1) Develop Sampling and Analysis Plans (SAPs) for water quality monitoring activities to be implemented.	• Begin development of SAPs for scheduled water quality monitoring to be conducted in 2004.	1-Feb-2004	To be initiated.
	• Final SAPs completed for 2004 scheduled monitoring.	31-Mar-2004	To be initiated.
	• Develop SAPs for any unscheduled water quality monitoring projects that are to be implemented.	Ongoing	SAP prepared for Missouri River California Bend dredging project.
2) Implement SAPs for Nebraska Lakes, North and South Dakota Tributary Reservoirs, and Mainstem Ambient monitoring projects.	• Initiate implementation of SAPs.	1-Apr-2003	Completed.
	• Conduct water quality sampling in accordance with SAPs.	1-May-2003 to 30-Sep-2003	Completed – A few targeted sample collection dates and parameters were missed.
	• Conduct data verification and validation in accordance with SAPs and appropriate water quality SOPs.	Ongoing	Completed.
	• Enter quality assured data into the DASLER database.	Ongoing	Completed.
3) Implement SAP for Missouri River monitoring project.	• Initiate implementation of SAPs.	1-Apr-2003	Completed.
	• Conduct water quality sampling in accordance with SAPs.	1-Apr-2003 to 31-Mar-2004	Ongoing – sampling is proceeding in accordance with SAP.
	• Conduct data verification and validation in accordance with SAPs and appropriate water quality SOPs.	Ongoing	Ongoing – verification and validation is proceeding in accordance with SAP.
	• Enter quality assured data into the DASLER database.	Ongoing	Ongoing – data entry is proceeding in accordance with SAP.

TABLE 1. Continued.

Action Items	Tasks	Target Dates	Progress
WATER QUALITY MONITORING AND ASSESSMENT ACTIONS (Continued)			
4) Implement SAP for Lake Sakakawea intensive survey. Intensive survey to collect baseline information and monitor water quality conditions related to the projected significant draw down of the reservoir.	• Initiate implementation of SAP.	1-Apr-2003	Completed.
	• Conduct water quality sampling in accordance with SAP.	1-May-2003 to 30-Sep-2003	Completed.
	• Conduct data verification and validation in accordance with SAP and appropriate water quality SOPs.	Ongoing	Ongoing.
	• Enter quality assured data into the DASLER database.	Ongoing	To be initiated.
	• Provide data/report to RCC in accordance with SAP.	Ongoing	Final preliminary report provided to RCC.
5) Implement SAP for Bear Creek Reservoir Aeration study.	• Initiate implementation of SAP.	1-Apr-2003	Study not conducted due to staffing constraints.
	• Conduct water quality sampling in accordance with SAP.	1-May-2003 to 30-Sep-2003	
	• Conduct data verification and validation in accordance with SAP and appropriate water quality SOPs.	Ongoing	
	• Enter quality assured data into the DASLER database.	Ongoing	
6) Implement SAPs for unscheduled water quality monitoring projects.	• As identified in appropriate SAPs.	See SAPs	Monitoring conducted to support Missouri River California Bend dredging project.
7) Prepare "Annual Report of Water Quality Conditions in the Omaha District".	• Begin compiling and assessing data.	1-Oct-2003	Data compiled and is being assessed.
	• Complete initial draft of report.	31-Dec-2003	Ongoing.
	• Complete final report.	31-Jan-2004	Ongoing.

TABLE 1. Continued.

Action Items	Tasks	Target Dates	Progress
DATA MANAGEMENT ACTIONS			
8) Develop a white paper that defines the Omaha District's water quality data management needs and identifies the approach that the District will use to manage its water quality data.	• Complete final white paper	15-Apr-2003	Final draft completed. Draft report is being revised to incorporate information gained by District staff that attended EPA STORET training in December 2003.
9) Implement water quality data management system.	• Determine if Stage Electronic Data Deliverable (SEDD) can be used to improve efficiency of data delivery from laboratory and data quality assessment.	Ongoing	To be initiated.
	• Enter District collected water quality data into DASLER in accordance with appropriate SAPs and SOPs.	Ongoing	Data being entered in accordance with SAPs and SOPs.
	• Enter historic and outside agency data into auxiliary DASLER database as appropriate.	Ongoing	To be initiated.
	• Set up the District's local STORET database to receive data from DASLER.	Ongoing	Completed.
	• Begin entering water quality data into the District's local STORET database.	1-Jul-2003	Ongoing.
	• Begin transferring District water quality data to EPA's national STORET database.	1-Oct-2003	To be initiated.
	• District's STORET database to include all appropriate water quality data from 1999 to present.	31-Mar-2004	To be initiated.
PROJECT WATER QUALITY MANAGEMENT PLANNING ACTIONS			
10) Develop water quality SOP number WQ-28001, "Development of Water Quality Management Plans for Omaha District Civil Works Projects."	• Develop initial draft of SOP.	Ongoing	To be initiated.

TABLE 1. Continued.

Action Items	Tasks	Target Dates	Progress
TECHNICAL SUPPORT ACTIONS			
11) Support Cheyenne River (South Dakota) contaminated sediment study.	• Provide technical input on surface water quality issues and draft text for report as needed.	Ongoing	Initial report completed.
12) Support Glenn Cunningham Reservoir (Omaha, Nebraska) Section 1135 study.	• Provide technical input on surface water quality issues and draft text for report as needed.	Ongoing	Ongoing.
13) Support Kingfisher Point (Ft. Collins, Colorado) Section 206 study.	• Provide technical input on aquatic habitat restoration issues and draft text for report as needed.	Ongoing	Ongoing.
14) Support implementation of the Ft. Peck Mini-Test.	• Provide water quality technical input and monitoring support needed to facilitate implementation of the Ft. Peck Mini-Test. (Note: Mini-Test currently on hold due to low reservoir level.)	Ongoing	Ongoing.
15) Provide technical support to other Corps echelons as requested and appropriate.	• Provide technical input on surface water quality issues.	Ongoing	Provided support on water quality issues involving litigation at Lake Sakakawea.
PROGRAM DEVELOPMENT AND EVALUATION ACTIONS			
16) Prepare "Annual Water Quality Management Program Report."	• Begin compiling information. • Complete final draft of report. • Complete final report.	1-Oct-2003 31-Dec-2003 31-Jan-2004	Revised to 1-Jan-2004. Ongoing. Revised to 31-Mar-2004. To be initiated. Revised to 30-Apr-2004. To be initiated.
17) Prepare water quality SOP number WQ-21105, "Shipment of Samples."	• Complete initial draft of SOP. • Complete final SOP.	1-Apr-2003 30-Apr-2003	Completed.
18) Prepare water quality SOP number WQ-21201, "Using a Hydrolab 4 & 4a to Directly Measure Water Quality."	• Complete initial draft of SOP. • Complete final SOP.	1-Apr-2003 30-Apr-2003	Completed.
19) Prepare water quality SOP number WQ-21105, "Determining Secchi Depth."	• Complete initial draft of SOP. • Complete final SOP.	1-Apr-2003 30-Apr-2003	Ongoing.

TABLE 1. (Continued)

Action Items	Tasks	Target Dates	Progress
PROGRAM DEVELOPMENT AND EVALUATION ACTIONS (Continued)			
20) Prepare water quality SOP number WQ-21204, "Determining Location Using Global Positioning System (GPS) Equipment."	• Complete initial draft of SOP. • Complete final SOP.	1-Apr-2003 30-Apr-2003	Completed.
21) Prepare water quality SOP number WQ-21207, "Using a --- to Directly Measure Water Quality." *[To be prepared if new equipment to be purchased are not Hydrolabs.]*	• Complete initial draft of SOP. • Complete final SOP. * 30 days after new equipment is received. ** 60 days after new equipment is received.	* **	Deleted. New equipment was not purchased.
22) Prepare water quality SOP number WQ-24101, "Establishing Station Numbers for Monitoring Sites."	• Complete initial draft of SOP. • Complete final SOP.	1-Jul-2003 31-Jul-2003	Ongoing.
23) Prepare water quality SOP number WQ-24102, "Defining Trip Numbers and Activity Codes for Data Collection Activities."	• Complete initial draft of SOP. • Complete final SOP.	1-Jul-2003 31-Jul-2003	To be initiated. Delayed to after staff received EPA STORET training.
24) Prepare water quality SOP number WQ-24103, "Identification and Documentation of Water Samples for Laboratory Analysis."	• Complete initial draft of SOP. • Complete final SOP.	1-Apr-2003 31-Apr-2003	Ongoing.
25) Prepare water quality SOP number WQ-24201, "Using the DASLER Data Management System."	• Complete initial draft of SOP. • Complete final SOP.	1-Jul-2003 31-Jul-2003	Ongoing.
26) Prepare water quality SOP number WQ-24102, "Using the STORET Data Management System."	• Complete initial draft of SOP. • Complete final SOP.	1-Sep-2003 30-Sep-2003	To be initiated. Delayed to after staff received EPA STORET training.
27) Prepare water quality SOP number WQ-26001, "Preparation of the Annual Report of Water Quality Conditions in the Omaha District."	• Complete initial draft of SOP. • Complete final SOP.	1-Sep-2003 30-Sep-2003	Ongoing.

TABLE 1. (Continued)

Action Items	Tasks	Target Dates	Progress
PROGRAM DEVELOPMENT AND EVALUATION ACTIONS (Continued)			
28) Prepare water quality SOP number WQ-27102, "Establishing Data Quality Objectives."	• Complete initial draft of SOP. • Complete final SOP.	1-Jan-2004 31-Jan-2004	To be initiated.
29) Prepare water quality SOP number WQ-27201, "Sampling Quality Control."	• Complete initial draft of SOP. • Complete final SOP.	1-Apr-2003 30-Apr-2003	Ongoing.
30) Prepare water quality SOP number WQ-28002, "Development of the Annual Program Management Plan for the Water Quality Management Program."	• Complete initial draft of SOP. • Complete final SOP.	1-Jan-2004 31-Jan-2004	Revised to 1-Mar-2004. To be initiated. Revised to 21-Mar-2004. To be initiated.
31) Prepare water quality SOP number WQ-28003, "Preparation of the Annual Water Quality Management Program Report."	• Complete initial draft of SOP. • Complete final SOP.	1-Oct-2003 31-Oct-2003	Revised to 1-Apr-2004. To be initiated. Revised to 30-Apri-2004. To be initiated.
INTERAGENCY COORDINATION ACTIONS			
32) Pursue partnerships with the States of South Dakota, North Dakota, and Montana regarding the collection of surface water quality data at District projects.	• Contact the appropriate State agencies and determine if there is any interest in partnering in the collection of surface water quality data at District projects.	Ongoing	State agencies contacted. No partnering agreements in the immediate future were available.
33) Implement a partnership with the Nebraska Department of Environmental Quality to collect and share water quality data on District projects and the Missouri River.	• Initiate implementation of SAP for data collection for the Missouri River monitoring projects. • Initiate implementation of SAP for data collection for the Nebraska Lakes monitoring projects.	1-Apr-2003 1-May-2003	SAP implementation ongoing. SAP implementation completed.
MISCELLANEOUS ACTIONS			
34) Prepare necessary PR&Cs for purchases by the Water Quality Unit.	• PR&Cs to be prepared in a timely manner.	Ongoing	Completed as necessary.
35) Maintenance of water quality monitoring equipment.	• Perform routine maintenance as required.	Ongoing	Completed as necessary.

3 ACTIVITIES PLANNED FOR FUTURE YEARS

3.1 WATER QUALITY DATA COLLECTION

TABLE 2. Planned Water Quality Monitoring by the Omaha District's Water Quality Unit for Corps Project Areas in the District over the next 5 years and the Intended Data Collection Approach.

Water Bodies to be Monitored	Long-Term Fixed Station Monitoring	Intensive Surveys	Special Studies	Watershed Assessments	Investigative Monitoring
Missouri River Mainstem Project Areas:					
• Fort Peck Lake, Lake Sakakawea	**X***	2004			**X****
• Lake Oahe	**X***	2005			**X****
• Lake Sharpe	**X***	2008			**X****
• Lake Francis Case	**X***	2006			**X****
• Lewis and Clark Lake	**X***	2007			**X****
• Lake Yankton (Gavins Point), Lake Pocasse (Oahe), Lake Audubon (Garrison)	2006				**X****
• Missouri River – Fort Randall Dam to Rulo, Nebraska	**X***				**X****
Nebraska Tributary Project Areas:					
• Bluestem Lake, Branched Oak Lake, Conestoga lake, East Twin Lake, Ed Zorinsky Lake, Glen Cunningham Lake, Olive Creek Lake, Pawnee Lake, Stagecoach Lake, Standing Bear Lake, Wagon Train Lake, Wehrspann Lake, West Twin Lake,	**X***				**X****
North Dakota Tributary Project Areas:					
• Bowman-Haley Lake, Pipestem Lake	2004 2007				**X****
South Dakota Tributary Project Areas:					
• Cold Brook Lake, Cottonwood Springs Lake	2005 2008				**X****

* Planned to be monitored every year.

** Investigative monitoring will be conducted as necessary and appropriate.

3.2 PROJECT-SPECIFIC WATER QUALITY MANAGEMENT PLANNING

3.2.1 MISSOURI RIVER MAINSTEM PROJECTS

TABLE 3. MAJOR WATER QUALITY MANAGEMENT PLANNING ACTIVITIES PLANNED FOR THE MISSOURI RIVER MAINSTEM PROJECTS.

Planning Activity	Fort Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavins Point
Application of CE-QUAL-W2 Hydrodynamic and Water Quality Model.	2004	2004	2005	2008	2006	2007
Development of project-specific water quality management plans.	2006	2005	2007	2010	2008	2009

3.2.2 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOADS (TMDLS)

- The District will participate, as appropriate, as a stakeholder in the development of Total Maximum Daily Loads (TMDLs) on Corps projects (see TMDL discussion in Section 6.1.2 and listing in Section 18.3).

4 CHANGES IN TECHNICAL CAPABILITIES

- A GS13 technical specialist position, Biological Sciences – Water Quality Specialist, was created and filled. The position resides in the Hydrologic Engineering Branch's Water Control and Water Quality Section and was an upgrade of an existing position within the Section's Water Quality Unit. The position was filled by a person from within the Water Quality Unit – the overall staffing of the Water Quality Unit did not change.

5 RELATIONSHIPS BETWEEN WATER QUALITY AND WATER CONTROL MANAGEMENT ACTIVITIES

5.1 GARRISON PROJECT – LAKE SAKAKAWEA

- A lawsuit was filed against the Corps by the State of North Dakota charging that the Corps management of water in the Garrison Project's Lake Sakakawea is impacting the attainment of a coldwater fishery in the lake, and is therefore a violation of North Dakota's water quality standards.

- The North Dakota lawsuit alleges that the Corps draw down of lake levels and the release of hypolimnetic water through the Garrison Dam's bottom outlet, after the lake has thermally stratified, reduces the occurrence of water that has the proper temperature and dissolved oxygen concentrations (i.e., temperature ≤ 15° C and dissolved oxygen concentration ≥ 5 mg/l) to support coldwater aquatic life. Under the current drought situation and the resultant lowered lake levels, North Dakota alleges that the reduction in the volume of water supportive of coldwater aquatic life, with regards to temperature and dissolved oxygen conditions, has reached a point where it violates the state's water quality standards.

5.2 GARRISON PROJECT – DAM RELEASES

- A continuous water quality data logger (i.e., water temperature, dissolved oxygen, pH, conductivity, ORP) was reestablished at the Garrison powerhouse. Hourly water quality conditions are recorded from raw water withdrawn from the penstock prior to the turbines. Early indications from this data are that due to the progression of thermal stratification and dissolved oxygen degradation in Lake Sakakawea through the summer, that the volume of water discharged through the dam has an affect on the quality of the water that is discharged. This affect is attributed to thermal stratification in Lake Sakakawea and where water is drawn from the lake with the differing volume of discharge through the dam.

6 PERTINENT REGULATIONS

6.1 FEDERAL CLEAN WATER ACT

6.1.1 WATER QUALITY STANDARDS

- Under Section 303 of the Clean Water Act, states adopt water quality standards that are approved by the U.S. Environmental Protection Agency (USEPA) and promulgated as state regulations.

- State water quality standards are applicable to all Corps projects in the District.

- The State of North Dakota filed a lawsuit alleging that the Corps operation of the Garrison Project is violating the state's water quality standards (see above discussion in Section 5).

6.1.2 TOTAL MAXIMUM DAILY LOADS

- Under Section 303(d) of the Federal Clean Water Act (CWA), States and Tribes, with the delegated authority from the USEPA, are required to prepare a biennial list of impaired waters [i.e., 303(d) list]. Impaired waters refer to those water bodies where it has been determined that technology-based effluent limitations required by Section 301 of the CWA are not stringent enough to attain and maintain applicable water quality standards. States and tribes, as appropriate, are required to establish and implement Total Maximum Daily Loads (TMDLs) for water bodies on their 303(d) lists.

- Corps project in the Omaha District have been listed on state 303(d) lists and TMDLs are being developed.

6.2 FEDERAL ENDANGERED SPECIES ACT

- Under Section 7 of the Federal Endangered Species Act, the U.S, Fish and Wildlife Service (USFWS) has issued a biological opinion of the operation of the Missouri River mainstem reservoir system, the operation and maintenance of the bank stabilization and navigation protect, and the operation of the Kansas River reservoir system.

- The USFWS's biological opinion, among other things, states that the Corps operation of the reviewed projects has had water quality impacts that are affecting the endangered pallid sturgeon. Specifically, water temperature, turbidity levels, and "nutrient" loads have been reduced such that it is having a deleterious affect on the pallid sturgeon. The biological opinion recommends that water temperature, turbidity, and nutrient loads be increased on targeted reaches of the Missouri River. See Section 18.3 for listing of Missouri River reaches where pallid sturgeon recovery is a concern.

7 LABORATORY FACILITIES

- The Omaha District utilizes the Corps Environmental Chemistry Branch (USACE-ECB) laboratory in Omaha, Nebraska.

- The USACE-ECB laboratory analyzes water quality samples "in-house" and contracts with outside laboratories when necessary.

- The utilization of contract laboratories for water quality samples collected by the Omaha District is managed by the USACE-ECB for the Omaha District.

8 DATA MANAGEMENT SYSTEMS

- Water quality data collected by the Omaha District prior to 1999 is maintained on USEPA's STORET legacy data management system. The Omaha District's agency code in the STORET system is COEOMAHA. The District plans to migrate a copy of this data to an internal District database.

- Water quality data collect after 1998 is currently maintained on an internal District database utilizing DASLER (Data Management and Analysis System for Lakes, Estuaries, and Rivers) software.

- The District is pursuing utilization of "modernized" STORET at this time.

9 TRAINING NEEDS

9.1 GENERAL TRAINING NEEDS

- Any training that would enhance the ability of Water Quality Unit staff to implement the District's Water Quality Management Program is encouraged.

- All full-time Water Quality Unit staff involved in water quality data collection and assessment are encouraged to take a college-level limnology course if they haven't done so.

- Training in monitoring design and statistical assessment of surface water quality conditions is a priority training need.

9.2 SPECIFIC TRAINING NEEDS

- Available courses identified for Water Quality Unit staff attendance.
  - "Wetland Construction for Water Quality Improvement" – USACE.
  - "Water Quality Management" – USACE.
  - "Design of Water Quality Monitoring Networks" – Colorado State University
  - "Environmental Statistics Short Course" – Colorado State University
  - "CE-QUAL-W2 Workshop" – Portland State University

10 RESEARCH AND DEVELOPMENT NEEDS

- Support necessary to allow the application of the CE-QUAL-W2 Hydrodynamic and Water Quality Model (Version 3.1) to the Missouri River Mainstem Project Reservoirs (see Section 3.2.1).

11 SPECIAL STUDIES COMPLETED OR REQUIRED

11.1 INTENSIVE SURVEYS CONDUCTED DURING 2003

- Garrison Project – Lake Sakakawea.

11.2 INTENSIVE SURVEYS NEEDED

- Fort Peck Lake, Lake Sakakawea, Lake Oahe, Lake Francis Case, Lewis and Clark Lake, Lake Sharpe (see Section 3.1).

12 WATER QUALITY COORDINATION WITH OTHER AGENCIES

- The District entered into an Interagency Support Agreement with the Nebraska Department of Environmental Quality to partner in monitoring Corps Projects (i.e., Papillion Creek Projects, Salt Creek Projects, and Missouri River) in Nebraska.

- Participated in meetings as a member of the Nebraska Surface Water Monitoring Council.

- Participated in stakeholder meetings regarding the development of a TMDL on the Missouri River below Fort Peck Dam in Montana.

- Coordinated with the Bear Creek, Chatfield, and Cherry Creek Watershed Authorities regarding sharing data on the Colorado Tributary Projects. At this time the Omaha District has discontinued water quality data collection at the Colorado Tributary Projects, and is utilizing data collected by the Watershed Authorities.

- Contacted all state water quality agencies regarding partnering possibilities in the collection water quality data at Corps projects.

13 SCHEDULING FOR DETAILED PROJECT EVALUATIONS

- See Section 3.2.1.

14 PROBLEMS ENCOUNTERED WITH CONTRACTED WORK

- None at this time.

15 IDENTIFICATION OF HINDRANCES TO MEETING GOALS AND OBJECTIVES AND PROPOSED SOLUTIONS FOR THEIR REMOVAL

15.1 HINDRANCES TO MEETING GOALS AND OBJECTIVES

- Lack of additional funding and potential cuts to water quality O&M funding.

15.2 SOLUTIONS

- Minimize funding cuts to water quality O&M funding.

- Intensive water quality surveys and the development of project-specific water quality management plans are planned over a longer time span than desired to remain within existing funding constraints.

- Water quality monitoring partnerships are being pursued to leverage, as much as possible, existing agency funding for water quality monitoring.

16 SPECIAL ASSISTANCE RECEIVED

16.1 COMMITTEE ON WATER QUALITY

- No special assistance was received from the Committee on Water Quality during 2003.

16.2 WATER OPERATIONS TECHNOLOGY SUPPORT PROGRAM

- Special assistance was received from the Corps Engineer Research & Development Center in Vicksburg, MS regarding the CE-QUAL-W2 model and evaluation of the coldwater fishery habitat relevant to the North Dakota lawsuit at Lake Sakakawea.

16.3 CORPS LABORATORIES

- The Omaha District utilized the Corps Environmental Chemistry Branch (USACE-ECB) laboratory in Omaha, Nebraska for all its water quality laboratory analysis needs.

16.4 HQUSACE

- No special assistance was received from HQUSACE during 2003.

17 OTHER INFORMATION REQUESTED BY HQUSACE

- No other information was requested by HQUSACE for inclusion in the 2003 Annual Report.

18 SUMMARY OF DISTRICT WATER QUALITY ISSUES

18.1 IDENTIFIED PRIORITY WATER QUALITY ISSUES

Priority water quality issues within the Omaha District are identified in the "Strategic Plan and Guidance for Implementing the Omaha District's Water Quality Management Program" (USACE-OD, 2003) and are shown in Table 4.

18.2 GENERAL WATER QUALITY CONCERNS

18.2.1 LAKE EUTROPHICATION AND HYPOLIMNETIC DISSOLVED OXYGEN DEPLETION

Reservoirs are commonly classified or grouped by trophic or nutrient status. The natural progression of water bodies through time is from an oligotrophic (i.e., low nutrient/low productivity) through a mesotrophic (i.e., intermediate nutrient/intermediate productivity) to a eutrophic (i.e., high nutrient/high productivity) condition. The tendency toward the eutrophic or nutrient-rich status is common to all impounded waters. The eutrophication or enrichment process can be accelerated by nutrient additions to the lake resulting from cultural activities.

As deeper, temperate lakes warm in the spring and summer they typically become thermally stratified, due to the density differences of the water, into three vertical zones: 1) epilimnion, 2) metalimnion, and 3) hypolimnion. The epilimnion is the upper zone of less dense, warmer water in the reservoir that remains relatively mixed due to wind action and convection. The metalimnion is the middle

Table 4. Priority Water Quality Issues Identified within the Omaha District.

General Water Quality Priorities:	Relative Priority Ranking*
• Provide water quality information to support Corps reservoir regulation elements for effective water quality and aquatic habitat management.	**4**
• Provide water quality information and technical support to the States in the development of their Section 303(d) lists and development and implementation of TMDLs at District projects.	**5**
• Identify existing and potential water quality problems at District projects, and develop and implement appropriate solutions.	**6**
• Evaluate water quality conditions and trends at District projects.	**7**
Specific Water Quality Priorities:	
• Determine how District operation of the Missouri River mainstem dams affects water quality in the impounded reservoir and downstream river. Utilize the CE-QUAL-W2 hydrodynamic and water quality model to facilitate this effort.	**1**
• Evaluate how eutrophication is progressing in the Missouri River mainstem reservoirs, especially regarding the expansion of anoxic conditions in the hypolimnion during summer stratification.	**2**
• Determine how flow regime, especially the release of water from Missouri River mainstem projects, affects water quality in the Missouri River.	**3**
• Determine how current water quality conditions in the Missouri River (e.g., water temperature, turbidity, etc.) may be affecting pallid sturgeon populations in the Missouri River system.	**8**

- 1 = Highest priority issue; 8 = lowest priority issue.

zone that represents the transition from warm surface water to cooler bottom water. The hypolimnion is the bottom zone of more dense, colder water that is relatively quiescent.

A significant water quality concern that can occur in eutrophic reservoirs that thermally stratify in the summer is the depletion of dissolved oxygen levels in the hypolimnion. The depletion of dissolved oxygen is attributed to the differing density of water with temperature, and the utilization of in-lake dissolved oxygen in the decomposition of organic matter and the oxidation of reduced inorganic substances. When density differences become significant, the deeper cooler water is isolated from the surface and re-oxygenation from the atmosphere. In eutrophic lakes, the decomposition of the abundant organic matter can significantly reduce dissolved oxygen in the quiescent hypolimnetic zone. Anoxic conditions in the hypolimnion can result in the release of sediment bound substances (e.g., phosphorus, metals, sulfides, etc.) as the reduced conditions increase, and result in the production of toxic and caustic substances (e.g., hydrogen sulfide, etc.). Most fish, and other intolerant aquatic life, cannot inhabit water with less than 4 to 5 milligrams per liter (mg/l) dissolved oxygen for extended periods. These conditions can impact aquatic life in the lake and also in waters downstream of the reservoir if its releases are from a bottom outlet.

18.2.2 SEDIMENTATION

Sedimentation is a process that reduces the usefulness of reservoirs. In the design and construction of reservoirs, the Corps will commonly allow for additional volume to accommodate sedimentation. The inflowing sediment can seriously affect the reservoir ecology, fisheries, and benthic aquatic life. The reservoir can suffer ecological damage before a volume function such as flood control is impacted. The influx of sediment eliminates fish habitat, adds nutrients, destroys aesthetics, and decreases biodiversity. Working closely with the project sponsors in an effort to manage sediment input

could ultimately prolong reservoir life. Wetlands or sediment traps could be constructed at the upper end of a reservoir either upstream of the reservoir, or by taking a portion of the reservoir's upper end.

18.2.3 SHORELINE EROSION

Shoreline erosion is a major problem occurring on nearly all reservoirs located in areas of erodible soils such as the Midwest. The Omaha District alone has over 6,000 miles of reservoir shoreline of which between 70 and 90 percent is eroding. Some locations have been protected, such as recreational and archaeological sites, but most of the shoreline continues to erode. Continued loss of the shoreline habitat (littoral zone) results in the loss of fishery habitat as well as loss of habitat for other biota such as aquatic vegetation and benthic invertebrates. Past shoreline erosion efforts should be evaluated for effectiveness so that successful control measures can be identified for future application.

18.2.4 BIOACCUMULATION OF CONTAMINANTS IN AQUATIC ORGANISMS

Bioaccumulation is the accumulation of contaminants in the tissue of organisms through any route, including respiration, ingestion, or direct contact with contaminated water or sediment. Bioavailable, for chemicals, is the state of being potentially available for biological uptake by an aquatic organism when that organism is processing or encountering a given environmental medium (e.g., the chemicals that can be extracted by the gills from the water as it passes through the respiratory cavity or the chemicals that are absorbed by internal membranes as the organism moves through or ingests sediment). In water, a chemical can exist in three different basic forms that affect availability to organisms: 1) dissolved, 2) sorbed to biotic or abiotic components and suspended in the water column or deposited on the bottom, and 3) incorporated (accumulated) into organisms. Bioconcentration is a process by which there is a net accumulation of a chemical directly from water into aquatic organisms resulting from simultaneous uptake (e.g., by gill or epithelial tissue) and elimination. Biomagnification is the result of the process of biocentration and bioaccumulation by which tissue concentrations of bioaccumulated chemicals increase as the chemical passes up through two or more trophic levels. The term implies an efficient transfer of a chemical from food to consumer, so that residue concentrations increase systematically from one trophic level to the next.

Bioaccumulation of contaminants can have a direct effect on aquatic organisms. These effects can be chronic (reduced growth, fecundity, etc.) and acute (lethality). The bioaccumulation of contaminants can also be a concern to human health when the contaminated tissue of aquatic organisms is consumed by humans.

Fish are capable of accumulating many toxic substances in excess of 1,000 times the concentrations found in surface waters. The public has expressed concerns on whether fish caught from Corps project waters are safe to consume. It is important that answers to public health concerns be based on substantiated knowledge of toxicants in fish fillets and the public health risks associated with measured toxicant concentrations. This type of information can be used by states when considering the issuance of fish consumption advisories. Fish consumption advisories have been issued for fish caught from certain District project waters. Mercury is the most prevalent contaminant leading to the issuance of fish consumption advisories in the Omaha District (see Table 5).

18.2.5 OCCURRENCE OF PESTICIDES

Pesticides are widely applied to agricultural and urban lands throughout the Omaha District. Pesticides detected at Corps projects in the Omaha District over the past 5 years include: cyanazine, atrazine, alachlor, diazinon, dachthal, metolachlor, dieldrin, simazine, metribuzin, propachlor, dicamba

and trifluralin. Many of these pesticides do not have state or federal numeric water quality criteria established.

18.2.6 URBANIZATION

Urbanization around many Omaha District reservoirs is occurring at a rapid pace. Reservoirs with urbanizing watersheds include Cherry Creek, Chatfield, and Bear Creek in the Denver, Colorado area; Holmes in the Lincoln, Nebraska area; and Ed Zorinsky, Glen Cunningham, Standing Bear, and Wehrspann in the Omaha, Nebraska area. Urbanization, to a much lesser degree, is occurring at other Corps projects in the District.

Construction methods used to develop urban areas disturb the land and allow sediment-laden runoff to impact nearby streams and lakes. Best management practices (BMPs) to minimize construction associated sedimentation damages are used ineffectively in many cases. BMPs to control the impact of construction practices include; sediment retention basins, phased "grading", and runoff control (e.g. hay bales, silt fences, vegetative ground cover, terracing, etc). Efforts need to be made to prevent sedimentation from off-project construction activities from causing impacts to Corps projects. This could be accomplished by the appropriate state, city, or county agencies working with developers.

Post construction problems are commonly associated with storm drainage and urban pollution. The conversion of grasslands or forests to roads, rooftops, sidewalks, and other water impervious surfaces make stream flows more variable and increases the frequency of high flow events. In addition, pollutants associated with urban drainage can cause severe impacts to downstream water bodies. Storm sewer exits can be allowed on project lands provided detention in the form of ponds, swales, or wetlands exist on private property. A developer may be asked to construct a series of wetlands to slow downhill flows and provide time for bacterial die-off, chemical degradation, reduced flow rates, and sediment fall out.

18.3 SUMMARY OF PROJECT WATER QUALITY CONCERNS

A summary of project water quality concerns is provided in Table 5.

18.4 PROBLEMS ENCOUNTERED AND HOW ADDRESSED

18.4.1 PROBLEM: ASSESSMENT OF COLWATER FISHERY HABITAT AT LAKE SAKAKAWEA

- How Addressed: The CE-QUAL-W2 Hydrodynamic and Water Quality Model is being applied and tested on Lake Sakakawea. Once "calibrated" the model will allow for a quantifiable assessment of coldwater fishery habitat in Lake Sakakawea and its response to Corps water control management operations.

18.4.2 PROBLEM: MISSED TARGET SAMPLING DATES FOR WATER QUALITY DATA COLLECTION AT THE NEBRASKA TRIBUTARY PROJECTS AND FORT PECK LAKE.

- How Addressed – Nebraska Tributary Lakes: Water Quality Unit staff responsibilities are being redefined to ensure staff are available to timely conduct sampling at the Nebraska Tributary Lakes.

- How Addressed – Fort Peck Lake: Sampling at Fort Peck Lake during 2004 will be under an intensive survey, and sampling will be conducted by Water Quality Unit rather than Project staff.

Table 5. Summary of Project Water Quality Concerns.

Project Area	TMDL Considerations*					Fish Consumption Advisories		Other Potential Water Quality Concerns
	On 303(d) List	Impaired Uses	Pollutant/Stressor	Probable Source	TMDL Completed	Advisory in Effect	Identified Contamination	
Missouri River Mainstem Projects:								
Fort Peck Lake	Yes	Drinking Water Supply Primary Contact Recreation	Lead Mercury Metals Noxious Aquatic Plants	Agriculture Resource Extraction Abandoned Mining Atmospheric Deposition Debris & Bottom Deposits	No	Yes	Mercury	
Missouri River below Fort Peck Dam	Yes	Aquatic Life Support Cold Water Fishery – Trout Drinking Water Supply Warm Water Fishery	Flow Alteration Metals Other Habitat Alterations Riparian Degradation Thermal Modifications	Hydromodification Upstream Impoundment Flow Regulation/Modification	No	No		Pallid sturgeon priority mgmt. area
Lake Sakakawea	Yes	Fish and Other Aquatic Biota Fish Consumption	Low Dissolved Oxygen Water Temperature Methyl-Mercury	Not identified	No	Yes	Mercury	Algal blooms Hypolimnetic dissolved oxygen
Missouri River below Garrison Dam	No					Yes	Mercury	
Lake Oahe	No					No		
Lake Sharpe	No**	No Specific Use Identified	Accumulated Sediment	Bad River Watershed	Yes	No		
Lake Francis Case	No					No		
Missouri River below Fort Randall Dam	No					No		National recreational river Pallid sturgeon priority mgmt. area
Lewis and Clark Lake	No					No		Sedimentation Emergent aquatic vegetation Hydrogen sulfide
Missouri River below Gavins Point Dam	Yes	Recreation	Pathogens	Agriculture	No	No		National recreational river Pallid sturgeon priority mgmt. area
Colorado Tributary Projects:								
Bear Creek Lake	No					No		Site specific water quality criteria (phosphorus and chlorophyll)
Chatfield Lake	No					No		Site specific water quality criteria (phosphorus and chlorophyll) Possible lake draw down
Cherry Creek Lake	Yes	Aquatic Life Recreation	Chlorophyll a	Not identified	Being Revised	No		Site specific water quality criteria (phosphorus and chlorophyll)
North Dakota Tributary Projects:								
Bowman-Haley Lake	No					Yes	Mercury	Algal blooms
Pipestem Lake	No					Yes	Mercury	Algal blooms
South Dakota Tributary Projects:								
Cold Brook Lake	No					No		Algal blooms
Cottonwood Springs Lake	No					No		Algal blooms

* Information taken from published state Total Maximum Daily Load (TMDL) 303(d) reports and listings.

** Lake Sharpe was removed from the State's 303(d) list with the development of a TMDL and the implementation of a Section 319 Nonpoint Source Management Project in the Bad River watershed.

Table 5. Continued.

Project Area	TMDL Considerations*					Fish Consumption Advisories		Other Potential Water Quality Concerns
	On 303(d) List	Impaired Uses	Pollutant/Stressor	Probable Source	TMDL Completed	Advisory in Effect	Identified Contamination	
Nebraska Tributary Projects:								
Bluestem Lake	Yes	Aquatic Life Aesthetics	Nutrients	Nonpoint source	No	No		
Branched Oak Lake	Yes	Aquatic Life Aesthetics	Nutrients	Nonpoint source	No	No		Algal blooms
Conestoga Lake	Yes	Aquatic Life Aesthetics	Nutrients Sedimentation	Nonpoint source	No	No		Algal blooms
East Twin Lake	Yes	Aquatic Life Aesthetics	Nutrients	Nonpoint source	No	No		
Ed Zorinsky Lake	Yes	Aquatic Life Aesthetics	Nutrients Sedimentation	Nonpoint source	Yes	Yes	Mercury	
Glenn Cunningham Lake	Yes	Aquatic Life Aesthetics	Nutrients Sedimentation	Nonpoint source	No	No		Fish kill
Holmes Lake	Yes	Aquatic Life Aesthetics	Nutrients Sedimentation	Point and nonpoint source	Yes	No		
Olive Creek Lake	Yes	Aquatic Life Aesthetics	Low dissolved oxygen Nutrients Sedimentation	Nonpoint source	No	No		Algal blooms
Pawnee Lake	Yes	Aquatic Life Aesthetics	Nutrients	Nonpoint source	Yes	No		Algal blooms
Stagecoach Lake	Yes	Aquatic Life Aesthetics	Nutrients Sedimentation	Point and nonpoint source	No	No		Algal blooms
Standing Bear Lake	Yes	Aquatic Life Aesthetics	Nutrients Sedimentation	Nonpoint source	Yes	No		
Wagon Train Lake	Yes	Aquatic Life Aesthetics	Low dissolved oxygen Nutrients	Nonpoint Source	Yes	No		Algal blooms
Wehrspann Lake	Yes	Aquatic Life Aesthetics	Nutrients	Nonpoint source	No	Yes	Mercury	Algal blooms
West Twin Lake	Yes	Aquatic Life Aesthetics	Low dissolved oxygen Nutrients	Nonpoint source	No	No		
Yankee Hill Lake	Yes	Aquatic Life Aesthetics	Nutrients Sedimentation	Nonpoint source	Yes	No		

* Information taken from published state Total Maximum Daily Load (TMDL) 303(d) reports and listings.

18.4.3 PROBLEM: IDENTIFIED FIELD MEASUREMENTS NOT COLLECTED AT FORK PECK LAKE.

- How Addressed: Problem was due largely to equipment failure. Sampling at Fort Peck Lake during 2004 will be under an intensive survey, and sampling will be conducted by Water Quality Unit rather than Project staff. Back-up equipment will be available.

18.4.4 PROBLEM: REQUESTED PARAMETERS NOT ANALYZED BY LABORATORY.

- How Addressed: A data requirements "check sheet" has been identified for inclusion in all Sampling and Analysis Plans (SAPs). Check sheet will identify "key" data needs such as: stations to be sampled, targeted sampling dates, parameters to be analyzed, parameter detection limits, etc. Check sheet will be made available to appropriate persons to reinforce data requirements. Staff responsibilities will be redefined to ensure that timely data verification occurs.

18.4.5 PROBLEM: IDENTIFIED DETECTION/REPORTING LIMITS NOT MET FOR ANALYZED PARAMETERS.

- How Addressed: A data requirements "check sheet" has been identified for inclusion in all Sampling and Analysis Plans (SAPs). Check sheet will identify "key" data needs such as: stations to be sampled, targeted sampling dates, parameters to be analyzed, parameter detection limits, etc. Check sheet will be made available to appropriate persons to reinforce data requirements. Staff responsibilities will be redefined to ensure that timely data verification occurs.

18.5 OPPORTUNITIES IDENTIFIED AND HOW ADDRESSED

- Opportunity: The Nebraska Department of Environmental Quality and the Omaha District are concerned about water quality conditions at Corps projects in Nebraska and both agencies were monitoring water quality at the same sites.

- How Addressed: An Interagency Support Agreement was established between the two agencies and we are now partnering in the collection of water quality data at Corps projects in Nebraska

18.6 INNOVATIVE TECHNIQUES UTILIZED TO IMPROVE WATER QUALITY

- No new innovative techniques were implemented in 2003 to improve water quality.

18.7 SPECIAL REGULATION ACTIVITIES

18.7.1 WATER QUALITY STANDARDS ATTAINMENT IN LAKE SAKAKAWEA

- Extensive water quality monitoring was conducted at Lake Sakakawea to evaluate the attainment of state water quality standards for the protection of a coldwater fishery use.

- Numerous declarations and affidavits that were submitted as part of the North Dakota lawsuit concerning alleged water quality standards violations at Lake Sakakawea were reviewed.

- Prepared a declaration that was submitted as part of the record for the North Dakota lawsuit.

18.7.2 DEVELOPMENT OF TMDLS

- Participated in stakeholder meetings regarding the development of a TMDL on the Missouri River below Fort Peck Dam in Montana.

18.8 NEW OR MODIFIED DATA COLLECTION PROGRAMS

18.8.1 WATER QUALITY MONITORING AT THE MISSOURI RIVER MAINSTEM DAMS

- Data-loggers were reestablished at all the Missouri River mainstem dams. Water is drawn from the penstock, prior to the turbines, and routed through in-place water quality monitoring equipment. Water quality conditions (i.e., water temperature, dissolved oxygen, pH, conductivity, ORP) are being recorded hourly year-round.

- Monthly water quality samples are being collected year-round at the locations of the installed data-loggers. The collected samples are transported to the USACE-ECB Laboratory (Omaha) and analyzed for numerous parameters.

18.8.2 WATER QUALITY INTENSIVE SURVEYS

- The first water quality survey planned for the Missouri River mainstem lakes was implemented.

18.8.3 WATER QUALITY MONITORING OF THE MISSOURI RIVER IN NEBRASKA

- The collection of water quality data at nine sites along the Missouri River from Fort Randall dam to Rulo, Nebraska was initiated. Samples are collected monthly from October through March, and biweekly from April through September. The collected samples are transported to the USACE-ECB Laboratory (Omaha) and analyzed for numerous parameters.

18.9 POSSIBLE CORPS-WIDE APPLICATION OF AVAILABLE DATA (E.G., R&D)

- Nothing identified for Corps-wide application.

18.10 ONGOING APPLIED RESEARCH

- The District is pursuing the application of the CE-QUAL-W2 Hydrodynamic and Water Quality Model (Version 3.1) to the Missouri River mainstem reservoirs.

18.11 CHANGES TO PROJECT WATER QUALITY OBJECTIVES

- The District has proposed a schedule for the development of project-specific water quality management plans (see Section 3.2.1).

18.12 REGULATION/OPERATION MODIFICATIONS FOR WATER QUALITY

- None during 2003.

18.13 MODIFICATIONS TO SAMPLING PROGRAMS AND OBJECTIVES

- A new monitoring strategy for the Omaha District's Water Quality Management Program was development and is included in the document, "Strategic Plan and Guidance for Implementing the Omaha District's Water Quality Management Program" (USACE-OD, 2003).

19 SUMMARY OF PROJECT-BY-PROJECT WATER QUALITY CONDITIONS

19.1 WATER QUALITY ASSESSMENT METHODS

19.1.1 2003 WATER QUALITY CONDITIONS – STATISTICAL SUMMARY AND WATER QUALITY STANDARDS ATTAINMENT

Summary statistics were calculated for water quality monitoring data collected during 2003, and the data were compared to applicable water quality standards established by the states pursuant to the Federal Clean Water Act (CWA.). Tables were constructed that list the parameters measured; number of observations; and the mean, median, minimum, and maximum of the data collected. The constructed tables also list the water quality standards criteria applicable to the individual parameters and the frequency that these criteria were exceeded.

19.1.2 SUMMER LAKE STRATIFICATION

A significant water quality concern that can occur in reservoirs that thermally stratify in the summer is the depletion of dissolved oxygen levels in the hypolimnion. This is a natural process attributed to the differing density of water with temperature, and the utilization of in-lake dissolved oxygen in the decomposition of organic matter and the oxidation of reduced inorganic substances. When the water density differences attributed to temperature become significant, the deeper cooler water is isolated from the surface and re-oxygenation from the atmosphere. In thermally stratified lakes, the deeper, quiescent waters can become anoxic and result in the release of sediment bound substances (e.g., phosphorus, metals, sulfides, etc.) as the reduced conditions increase. Anoxic conditions can also result in the production of toxic and caustic substances (e.g., hydrogen sulfide, etc.). These conditions can impact aquatic life in the lake and also in waters downstream of the reservoir if releases are from a bottom outlet. Most fish cannot inhabit water with less than 4 to 5 milligrams per liter (mg/l) dissolved oxygen for extended periods.

Existing summer thermal stratification and hypolimnetic dissolved oxygen conditions were evaluated at Missouri River mainstem reservoirs based on monitoring results obtained during the past five years (i.e., 1999 to 2003). The data evaluated consisted of depth-profile measurements collected during the period May through September at in-lake long-term fixed station and intensive monitoring survey sites. Temperature and dissolved oxygen depth profiles were constructed and plotted for evaluation.

19.1.3 LAKE TROPHIC CONDITIONS

Reservoirs are commonly classified or grouped by trophic or nutrient status. The natural progression of lakes through time is from an oligotrophic (i.e., low nutrient/low productivity) through a mesotrophic (i.e., intermediate nutrient/intermediate productivity) to a eutrophic (i.e., high nutrient/high productivity) condition. The prefixes "ultra" and "hyper" are sometimes added to oligotrophic or eutrophic, respectively, as additional degrees of trophic status. The tendency toward the eutrophic or

nutrient-rich status is common to all impounded waters. The eutrophication or enrichment process can adversely impact water quality conditions in lakes (e.g., increased occurrence of algal blooms, noxious odors, and fish kills; reduced water clarity; reduced hypolimnetic dissolved oxygen concentrations; etc.). Eutrophication of lakes can be accelerated by nutrient additions through cultural activities (e.g., point-source discharges and nonpoint sources such as runoff from cropland, livestock facilities, urban areas, etc.).

A trophic state index (TSI) can be calculated as described by Carlson (1977). TSI values are determined from Secchi disk transparency, total phosphorus, and chlorophyll *a* measurements. Values for these three parameters are converted to an index number ranging from 0 to 100 according to the following equations:

$$TSI(\text{Secchi Depth}) = TSI(SD) = 10[6 - (\ln SD/\ln 2)]$$
$$TSI(\text{Chlorophyll } a) = TSI(Chl) = 10[6 - ((2.04-0.68 \ln Chl)/\ln 2)]$$
$$TSI(\text{Total Phosphorus}) = TSI(TP) = 10[6 - (\ln (48/TP)/\ln 2)]$$

Accurate TSI values from total phosphorus depend on the assumptions that phosphorus is the major limiting factor for algal growth and that the concentrations of all forms of phosphorus present are a function of algal biomass. While accurate TSI values from Secchi disk transparency depend on the assumption that water clarity is primarily limited by phytoplankton biomass. Carlson indicates that the chlorophyll TSI value may be a better indicator of a lake's trophic conditions during mid-summer when algal productivity is at its maximum, while the total phosphorus TSI value may be a better indicator in the spring and fall when algal biomass is below its potential maximum. Calculation of TSI values from data collected from a lake's epilimnion during summer stratification provide the best agreement between all the index parameters and facilitate comparisons between lakes. Care should be taken if a TSI average score is calculated from the three individual parameter TSI values. Because if significant differences exist between parameter TSI values, the calculated average value may not be indicative of the trophic condition estimated by the individual parameter values. With this in mind, a TSI average value [TSI(Avg)] calculated as the average of the three individually determined TSI values [i.e., TSI(SD), TSI(Chl), and TSI(TP)] is used by the Omaha District as an overall indicator of a lake's trophic state. The Omaha District uses the following criteria for determining lake trophic status from TSI values.

TSI	Trophic Condition
0-35	Oligotrophic
36-50	Mesotrophic
51-55	Moderately Eutrophic
56-65	Eutrophic
66-100	Hypereutrophic

In addition to classifying lakes, the TSI can serve as an internal check on the assumptions about the relationships among various components of a lake's ecosystem. Carlson states that that the three TSI parameters when transformed to the trophic scale should have similar values. Any divergence from this value by one or more of the parameters may provide insights into a lake's water quality dynamics (e.g., is the lake phosphorus limited, is water clarity limited by algae or nonalgal particulate matter, etc.)

Existing trophic conditions were assessed at Omaha District project lakes based on monitoring results obtained during the past five years (i.e., 1999 to 2003). The data evaluated consisted of Secchi depth measurements and total phosphorus and chlorophyll *a* analytical results obtained during the period May through September at in-lake long-term fixed station monitoring and intensive survey sites. TSI values were calculated and compared to the above criteria.

19.2 MISSOURI RIVER MAINSTEM PROJECTS

Corps projects on the Missouri River mainstem in the Omaha District include six dams and their associated lakes on the upper river, and the Bank Stabilization and Navigation Project on the lower river (i.e., reach of river below Sioux City, Iowa). The six Corps projects involving the operation of dams and their associated lakes are, from upstream to downstream, Fort Peck, Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point. Water quality monitoring was conducted by the Omaha District at each of these six projects and on the lower river during 2003.

Water quality monitoring targeted at the six dam projects for 2003 included: 1) continuing the long-term fixed station monitoring at the previously monitored in-lake deepwater and tailwaters locations, 2) reestablishment of a continuous (i.e., hourly) monitoring station in the powerhouse at each dam, and 3) intensive surveys. The continuing long-term fixed station monitoring was to consist of monthly (i.e., May through September) field measurements and sample collection at the previously monitored in-lake deepwater site near the dam and in the dam tailwaters. Table 6 lists the field measurements and sample analyses that were targeted for the in-lake and tailwater sites. The water to be monitored at the powerhouse sites is water drawn from the penstock prior to passing through the dam's turbines. Water quality conditions targeted for monitoring at the powerhouse sites include: temperature, dissolved oxygen, pH, conductivity, and oxidation-reduction potential (ORP). The powerhouse monitoring stations at each of the mainstem projects became operational during 2003 as follows: Fort Peck (July), Garrison (June), Oahe (September), Big Bend (September), Fort Randall (September), and Gavins Point (June). During 2003, a water quality intensive survey was conducted at the Garrison project.

19.2.1 FORT PECK

19.2.1.1 Background Information

Fort Peck Dam is located in eastern Montana, 18 miles southeast of Glasgow, Montana at river mile 1771 of the Missouri River. The closing of Fort Peck Dam in 1937 resulted in the formation of Fort Peck Lake that is 134 miles long and covers 246,000 acres when full. The lake and dam are used for flood control, irrigation, navigation, hydropower, domestic and sanitary use, fish and wildlife, and recreation. Fort Peck Lake is used as a water supply by the cities of Fort Peck and Glasgow, Montana and by numerous individual cabins in the area. Major inflows to Fort Peck Lake are the Missouri River, Musselshell River, and Little Dry Creek.

Pursuant to the Federal CWA, the State of Montana has given Fort Peck Reservoir a B-3 classification. As such, the lake is to be maintained suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply. Also pursuant to the CWA, the State of Montana has placed Fort Peck Lake on the state's Section 303(d) list of impaired waters citing impairment to the uses of drinking water supply and primary contact recreation due to the pollutants of lead, mercury, metals, and noxious aquatic plants. The identified sources of these pollutants are agriculture, resource extraction, abandoned mining, atmospheric deposition, debris, and bottom deposits. The State of Montana has also issued a fish consumption advisory for Fort Peck Lake due to mercury concerns.

Inflow to Fort Peck Lake averages approximately 7 million acre-feet (MAF) per year. Since filling to the base of the annual flood control zone (elevation 2234 feet and 15 MAF) in 1964, Fort Peck Lake filled into this zone each year until 1988. From 1988 through the summer of 1993, the lake was from 10 to 20 feet and 4 to 6 MAF below normal levels. Fort Peck Lake also fell below the base of the annual flood control zone during the current drought, which began in 2000. Currently, Fort Peck Lake is

Table 6. Targeted Water Quality Monitoring at In-Lake and Tailwater Long-Term Fixed Station Mainstem Sites.

Parameter	In-Lake Deepwater Site		Tailwater Site
	Near Surface*	Near Bottom*	
Total Suspended Solids	X	X	X
Total Kjeldahl Nitrogen	X	X	X
Nitrate/Nitrite Nitrogen	X	X	X
Total Ammonia Nitrogen	X	X	X
Total Phosphorus	X	X	X
Dissolved Orthophosphorus	X	X	X
Alkalinity	X	X	X
Total Organic Carbon	X		X
Chemical Oxygen Demand			X
Chlorophyll *a*	X		X
Pesticides			
• Complete Scan (May) **	X		X
• Rapid Assay (immunoassay)***	X		X
Metals****	X		X
Water Transparency (Secchi Disk)	X		X
Profile*****	X		X

* Near-surface sample collected at ½ the Secchi depth and the hypolimnetic sample is collected at approximately 1 meter above the lake bottom.

** One complete pesticide scan in May. The complete pesticide scan includes: acetochlor, alachlor, atrazine, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, pebulate, pendimenthalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin and vernolate.

*** Rapid Assay (immunoassay) for atrazine, alachlor, and metolachlor at all times.

**** Only analyzed for in the month of August. Dissolved metals to be analyzed: Ag, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Ti, and Zn. Total metals to be analyzed Hg and Se. Hardness will also be calculated from Ca and Mg concentrations.

***** Profile measurements are taken every meter from the surface to bottom at the deepwater site and at the surface at the tailwater site. Measurements to be taken include: temperature, dissolved oxygen, pH, conductivity, and ORP.

near or below historic low water conditions. Water discharged through Fort Peck Dam is withdrawn from Fort Peck Lake at elevation 2095 feet – approximately 65 feet above the lake bottom.

19.2.1.2 2003 Water Quality Conditions

Appendices A.1 and A.2 summarize the water quality conditions that were respectively monitored in Fort Peck Lake and the tailwaters of Fort Peck Dam during 2003. A review of these results found no significant water quality concerns. The only water quality standards criteria exceeded were water temperature and dissolved oxygen for the protection of Class B-2 "coldwater" aquatic life. Approximately 12% of the recorded temperature observations exceeded 19.4°C, with the maximum temperature recorded being 20.5°C. Montana's water quality standards' indicate 67°F (19.4°C) is the upper limit for supporting "coldwater" aquatic life. One recorded dissolved oxygen measurement (i.e., < 1% of the total measurements) was less than 5.0 mg/l – the lower limit identified by the Montana's water quality standards for the protection of "coldwater" aquatic life exposed directly to the water column. It is

noted that Montana's water quality standards do not directly classify Fort Peck Lake as B-2, but rather as B-3 (i.e., "warmwater" aquatic life). Coldwater aquatic life species are known to inhabit and reproduce in Fort Peck Lake; therefore, coldwater aquatic life is considered an existing use for protection under Montana's water quality standards' antidegradation policy.

1.1.1.1 Existing Summer Temperature and Dissolved Oxygen Conditions

Existing summer thermal stratification and hypolimnetic dissolved oxygen conditions were determined for Fort Peck Lake based on monitoring results obtained during the past five years (i.e., 1999 to 2003) at the in-lake long-term fixed station monitoring site. Temperature and dissolved oxygen depth profiles were constructed from water quality data collected during the period May through September (Appendices A.3 and A.4). Appendix A.3 shows that a significant temperature gradient does periodically exist in Ft. Peck Lake during this period with a thermocline becoming established at a depth of about 20 meters. There doesn't appear to be a significant gradient in summer dissolved oxygen levels in Fort Peck Lake (Appendix A.4). Appendix A.4 indicates that on all but one occasion, dissolved oxygen levels remained above 5 mg/l in the lower depths of Fort Peck Lake.

1.1.1.2 Existing Lake Trophic Conditions

TSI values for Fort Peck Lake were calculated from monitoring data collected during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring site. Table 7 summarizes the TSI values calculated for Fort Peck Lake. The TSI values seem to indicate that Fort Peck Lake is in a mesotrophic to moderately eutrophic trophic state. It is noted that the 5-year period 1999-2003 has been a period of extended drought in the area of Fort Peck Lake, and the drought conditions may have had an influence on the lake water quality parameters used to calculate the TSI values.

Table 7. Summary of Trophic State Index (TSI) Values Calculated for Fort Peck Lake for the 5-year Period 1999-2003.

TSI*	No. of Obs.	Mean	Median	Minimum	Maximum
TSI(SD)	14	37	37	30	44
TSI(Chl)	9	60	69	40	82
TSI(TP)	15	52	52	41	74
TSI(Avg)	5	51	50	45	58

* See text for explanation.

1.1.2 GARRISON

1.1.2.1 Background Information

Garrison Dam is located in central North Dakota, 75 miles northwest of Bismarck, North Dakota at river mile 1389 of the Missouri River. The closing of Garrison Dam in 1953 resulted in the formation of Lake Sakakawea that is 178 miles long and covers 380,000 acres when full. The lake and dam are used for flood control, irrigation, navigation, hydropower, domestic and sanitary use, fish and wildlife, and recreation. The lake is used as a water supply by some individual cabins and by the cities of Four Bears, Mandaree, Park City, Parshall, Riverdale, Trenton, Twin Buttes, and Williston, North Dakota. Major inflows to Lake Sakakawea are the Missouri River, Yellowstone River, and Little Missouri River.

Pursuant to the Federal Clean Water Act (CWA), the State of North Dakota has designated Lake Sakakawea as a Class 1 lake. As such, the lake is to be suitable for the propagation and/or protection of a

coldwater fishery (i.e., salmonid fishes and associated aquatic biota); swimming, boating, and other water recreation; irrigation; stock watering; wildlife; and for municipal or domestic use after appropriate treatment. Also pursuant to the CWA, the State of North Dakota has placed Lake Sakakawea on the state's Section 303(d) list of impaired waters citing impairment to the uses of fish and other aquatic biota and fish consumption due to the pollutants/stressors of low dissolved oxygen, water temperature, and methyl-mercury. The State of North Dakota has also issued a fish consumption advisory for Lake Sakakawea due to mercury concerns.

Since it was filled to the base of the annual flood control zone (elevation 1837.5 feet and 18.1 MAF) in 1965, Lake Sakakawea has filled into this zone each year except 1981, during the 1987 to 1993 drought, and during the current drought which began in 2000. From 1988 through June 1993, the lake was 10 to 20 feet (4 to 6 MAF) below the base of the annual flood control zone. The lake is currently near or below historic low water conditions. Water discharged through Garrison Dam is withdrawn from Lake Sakakawea at elevation 1672.5 – approximately 2 feet above the lake bottom.

19.2.2.2 2003 Intensive Water Quality Survey

19.2.2.2.1 Overview

A water quality intensive survey was conducted at the Garrison Project in 2003. The objectives of this survey were: 1) empirically evaluate the "coldwater habitat" present in Lake Sakakawea, and 2) collect the water quality data necessary to initiate application of the CE-QUAL-W2 Hydrodynamic and Water Quality Model (Version 3.1) to Lake Sakakawea. Water quality monitoring was conducted from June through September at 8 in-lake sites (i.e., IP1 – IP8), 2 inflow sites [i.e., Missouri River (BC1) and Little Missouri River (BC2)], and 1 outflow site [i.e., Garrison Dam powerhouse (BC4)] during 2003 (Figure 1). The 8 in-lake sites were associated with the following zones within the reservoir: 1) riverine zone – Sites IP7 and IP8; 2) zone of transition – Sites IP5 and IP6; and 3) lacustrine zone – Sites IP1, IP2, IP3, and IP4 (USACE, 1987).

Biweekly field measurements obtained at the 11 sites included: temperature, dissolved oxygen, conductivity, ORP, and turbidity. At the 8 in-lake sites the field measurements were taken as a 1-meter interval depth profile and Secchi depth was also determined. Field measurements at the 2 inflow sites were taken at the water surface. Field measurements at the outflow site were determined on water drawn from the penstock prior to discharge through the dam's turbines at the powerhouse site. Monthly (in-lake sites) and biweekly (inflow sites) water quality samples were collected at the 11 sites for laboratory analyses. The parameters analyzed were selected based on their application to the CE-QUAL-W2 water quality model (i.e., dissolved and suspended solids, nutrients, alkalinity, chlorophyll, sulfate, silica, iron, manganese, phytoplankton, and zooplankton).

19.2.2.2.2 Summary of Monitored Water Quality Conditions

Appendices A.5 and A.6 summarize the water quality conditions that were monitored at the 11 intensive survey monitoring sites. Appendix A.7 summarizes the attainment of applicable state water quality standards based on the monitored conditions. Water quality criteria exceeded at the 8 in-lake monitoring sites included those for dissolved oxygen, pH, and total phosphorus (Appendix A.7). Of the three parameters, the 5.0 mg/l criterion for dissolved oxygen was the one exceeded most often. Water quality criteria exceeded at the two inflow sites included total phosphorus, nitrates, and sulfates. The total phosphorus and sulfate criteria were exceed 100% of the time at Site BC2 (i.e. Little Missouri River). The only criterion exceeded at the outflow site BC4 was for dissolved oxygen, where it was exceeded 8% of the time. The exceedences of the dissolved oxygen criterion at the in-lake and outflow sites was attributed to low dissolved oxygen levels that occurred in the hypolimnion during late summer. The low

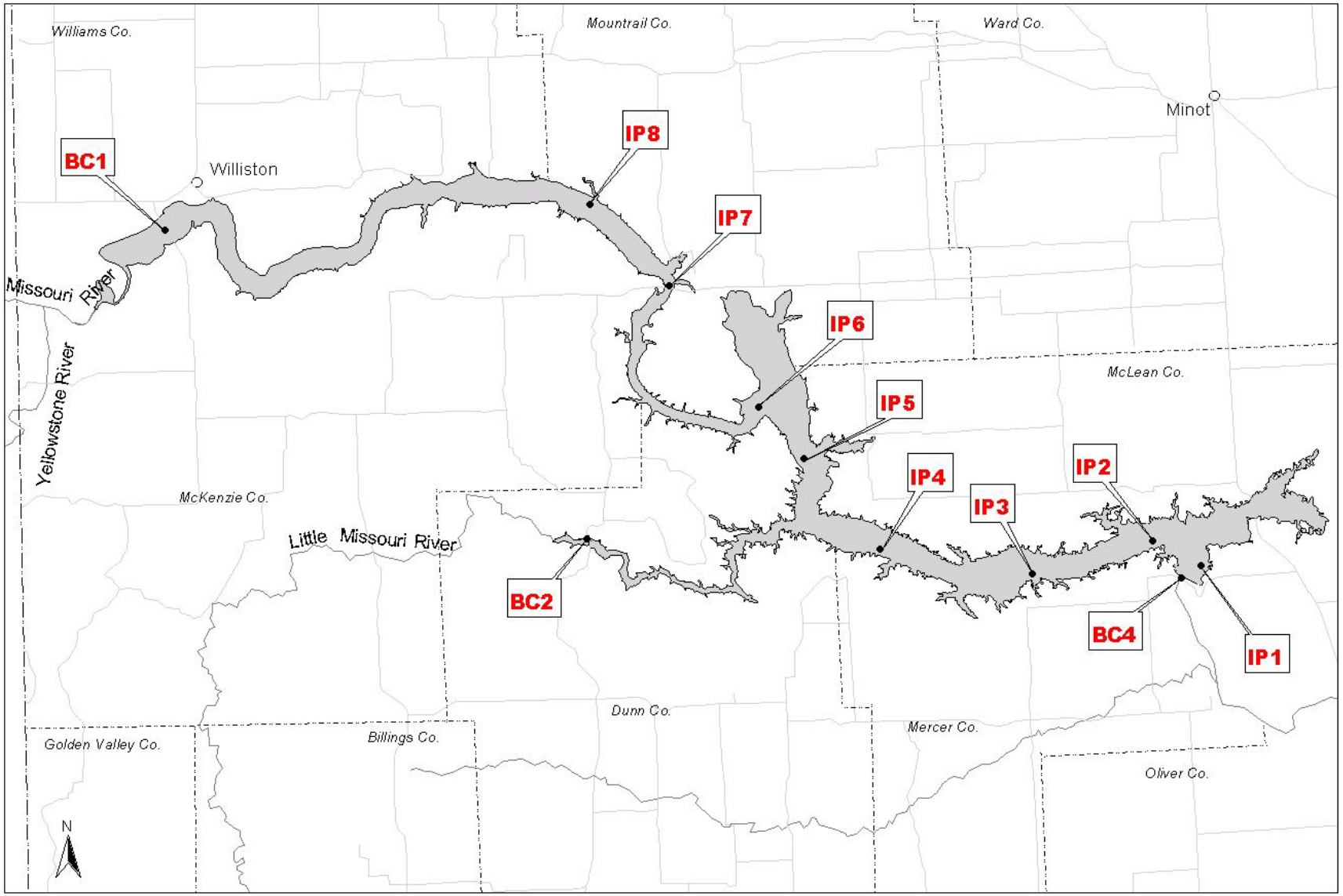


Figure 1. Sites Monitored as Part of the 2003 Garrison Project Intensive Water Quality Survey.

dissolved oxygen levels that were observed in the deeper areas of Lake Sakakawea was attributed to the quiescent nature of the hypolimnion, the decomposition of accumulated organic matter, and the utilization of dissolved oxygen to satisfy sediment oxygen demand.

Appendix A.8 plots the median values of selected parameters determined for the 11 monitoring sites. For comparison purposes, the monitoring sites are ordered relative to their respective location from upstream to downstream (i.e., BC1, IP8, IP7, IP6, IP5, BC2, IP4, IP3, IP2, IP1, BC4). Site BC4 was placed between Sites IP5 and IP6, as the Little Missouri River enters Lake Sakakawea between these two sites (Figure 1). As shown in Appendix A.8, generally water temperature decreased, dissolved oxygen increased, alkalinity increased, sulfates increased, specific conductance increased, total dissolved solids increased, total suspended solids decreased, turbidity decreased, Secchi depth increased, total phosphorus deceased, and chlorophyll *a* decreased in a downstream direction within the lake. Total Kjeldahl nitrogen, total ammonia nitrogen, nitrates-nitrites, pH, and total organic carbon showed little longitudinal variation in the lake. Although the monitored concentrations of several parameters (i.e. sulfates, specific conductance, total dissolved solids, total suspended solids, turbidity, total Kjeldahl nitrogen, nitrates-nitrites, total phosphorus, and total organic carbon) were much greater in the Little Missouri River (Site BC4), the delivered load does not appear to be great enough to have an appreciable affect on the water quality conditions in Lake Sakakawea, as little noticeable difference was observed in these parameters between Sites IP5 and IP6. Based on flow records over the past 10 years, the annual flow entering Lake Sakakawea from the Missouri River is approximately 40 times greater than the annual flow entering the lake from the Little Missouri River.

19.2.2.2.3 Summary of Lake Trophic Conditions

Trophic State Index (TSI) values for Lake Sakakawea were calculated from the monitoring data collected at the in-lake monitoring sites during 2003 (Table 8). The TSI values seem to indicate that the lacustrine zone of the lakes (i.e., Site IP1, IP2, IP3, and IP4) is mesotrophic, the transition zone (i.e., Sites IP5 and IP6) is moderately eutrophic, and the riverine zone (i.e., Sites IP7 and IP8) is eutrophic. However, it is noted that the calculated trophic state for the riverine zone is greatly influence by the lack of water clarity in this part of the lake. The reduced water clarity at Sites IP7 and IP8 was largely attributed to turbidity from runoff flowing into the lake from the Missouri River. It is noted that 2003 was a period of continuing drought in the area of Lake Sakakawea, and the drought conditions may have had an influence on the lake water quality parameters used to calculate the TSI values.

19.2.2.2.4 Occurrence of Coldwater Habitat

Water temperature and dissolved oxygen levels are primary water quality factors that determine the suitability of water for supporting coldwater aquatic life. Water quality standards for the protection of coldwater aquatic life typically define numeric temperature and dissolved oxygen criteria necessary to support the use. These criteria may be further delineated based on habitat types, life stages (i.e., spawning, early-life stages, and adults), and acute and chronic effects. The State of North Dakota's water quality standards do not define numeric temperature criteria for the protection of coldwater aquatic life, and define only a single dissolved oxygen criterion (i.e., 5.0 mg/l) for the protection of aquatic life. Therefore, the combination of temperature and dissolved oxygen conditions identified in Table 9 were used to evaluate the potential occurrence of coldwater habitat in Lake Sakakawea during 2003.

The Omaha District is currently pursuing the application of the CE-QUAL-W2 Hydrodynamic and Water Quality Model to Lake Sakakawea. When completed, the mechanistic model will facilitate estimation of coldwater habitat in the lake. At this point however, the occurrence of coldwater habitat was estimated using the temperature and dissolved oxygen depth profiles taken at Sites IP1 - IP8 (Figure 1), and the lake elevation and lake volume relationships defined by Houston Engineering in its Lake Sakakawea database for the report "Lake Sakakawea Analysis of Cold Water Habitat" (H.E.I., 2003).

Table 8. Summary of Trophic State Index (TSI) Values Calculated for Lake Sakakawea Based on Data Collected During the 2003 Intensive Survey.

Trophic State Index*	IP1	IP2	IP3	IP4	IP5	IP6	IP7	IP8
TSI – Secchi Depth								
• No. of Obs.	8	8	8	8	7	7	7	5
• Mean	42	43	44	46	50	59	70	76
• Median	44	44	44	45	49	57	67	75
• Minimum	35	38	41	44	45	54	61	71
• Maximum	47	47	48	53	61	71	80	83
TSI – Total Phosphorus								
• No. of Obs.	3	3	3	3	3	3	4	3
• Mean	49	54	48	50	54	57	53	60
• Median	52	55	48	52	55	55	53	61
• Minimum	34	48	48	48	52	52	48	57
• Maximum	61	60	48	52	55	66	57	63
TSI – Chlorophyll *a*								
• No. of Obs.	4	4	4	4	4	3	4	3
• Mean	36	34	36	39	44	45	39	44
• Median	37	34	36	39	45	46	39	44
• Minimum	31	31	31	37	37	41	31	41
• Maximum	37	37	41	41	51	46	46	46
TSI – Average								
• No. of Obs.	3	3	3	3	3	3	4	3
• Mean	41	43	44	44	50	54	54	60
• Median	41	43	44	44	48	55	54	61
• Minimum	39	40	42	44	45	52	50	56
• Maximum	44	45	46	45	56	56	58	63

* See text for explanation.

Table 9. Coldwater Habitat Conditions based on Water Temperature and Dissolved Oxygen Concentrations.

Coldwater Habitat	Water Temperature	Dissolved Oxygen
Class 1	> 15°C and ≤ 18°C	≥ 5 mg/l
Class 2	≤ 15°C	≥ 5 mg/l
Class 3	≤ 15°C	≥ 4.5 mg/l and < 5 mg/l

Appendix A.9 depicts the estimated occurrence of coldwater habitat present in Lake Sakakawea during 2003. As shown in Appendix A.9, Class 2 coldwater habitat in Lake Sakakawea decreased throughout the sampled period -- ranging from a high of about 8,558,000 acre-feet on June 17-18 to a low of about 233,000 acre-feet on September 23. Class 1 coldwater habitat also generally decreased through most of the sampled period. However, a very significant increase in Class 1 coldwater habitat occurred between the September 9-10 and September 23 (Appendix A.9). This was attributed to cooling of water temperatures and "fall overturn" of the lake. It was observed that near isothermal conditions existed at Sites IP1, IP2 IP3, and IP4 on September 23 at a temperature of about 17°C. Only the very lower depths of the lake at these sites exhibited colder water temperatures. This was an indication that the entire lake water column had not yet completely mixed and "turned over". The large volume of water in the lake at

about 17°C, due to "turnover" of the lake, met the Class 1 coldwater criteria but not the Class 2 coldwater criteria. The decrease of coldwater habitat observed over the sampled period is attributed to a warming of the lake and a reduction of dissolved oxygen in the lower depths as the summer progressed.

19.2.2.3 Existing Summer Lake Temperature and Dissolved Oxygen Conditions

Existing summer thermal stratification and hypolimnetic dissolved oxygen conditions were determined for Lake Sakakawea based on monitoring results obtained during the past five years (i.e., 1999 to 2003) at the in-lake long-term fixed station monitoring site. Temperature and dissolved oxygen depth profiles were constructed from water quality data collected during the period May through September (Appendices A.10 and A.11). Appendix A.10 shows that a significant temperature gradient does periodically exist in Lake Sakakawea during this period with a thermocline becoming established at a depth of about 25 meters. There does appear to be a gradient in summer dissolved oxygen levels in Lake Sakakawea (Appendix A.11). Appendix A.11 indicates that dissolved oxygen levels do approach and go below 5 mg/l in the lower depths of the lake.

19.2.2.4 Existing Lake Trophic Conditions

TSI values for Lake Sakakawea were calculated from monitoring data collected during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring site. Table 10 summarizes the TSI values calculated for Lake. The TSI values seem to indicate that Lake Sakakawea is in a mesotrophic state. It is noted that the 5-year period 1999-2003 has been a period of extended drought in the area of Lake Sakakawea, and the drought conditions may have had an influence on the lake water quality parameters used to calculate the TSI values.

Table 10. Summary of Trophic State Index (TSI) Values Calculated for Lake Sakakawea for the 5-year Period 1999-2003.

TSI*	No. of Obs.	Mean	Median	Minimum	Maximum
TSI(SD)	22	43	44	35	53
TSI(TP)	23	46	48	34	61
TSI(Chl)	11	36	37	24	55
TSI(Avg)	9	43	42	38	48

* See text for explanation.

19.2.3 OAHE

19.2.3.1 Background Information

Oahe Dam is located in central South Dakota 6 miles northwest of Pierre, South Dakota at river mile 1072 of the Missouri River. The closing of Oahe Dam in 1958 resulted in the formation of Lake Oahe which is 231 miles long and covers 374,000 acres when full. The lake and dam are used for flood control, irrigation, navigation, hydropower, domestic and sanitary use, fish and wildlife, and recreation. Lake Oahe is used as a water supply by the town of Fort Yates, North Dakota, and the towns of Bear Creek, Blackfoot, Bridger, Cherry Creek, Dupree, Eagle Butte, Faith, Gettysburg, Green Grass, Iron Lightning, Lantry, LaPlante, Mobridge, Promise, Red Elm, Red Schaffold, Swiftbird, Thunder Butte, Wakpala, and White Horse, South Dakota, as well as some individual cabins. Major inflows to Lake Oahe are the Missouri River and Cheyenne River.

Pursuant to the Federal Clean Water Act (CWA), the State of South Dakota has designated the following water quality-dependent beneficial uses for Lake Oahe: recreation (i.e., immersion and limited-contact), coldwater permanent fish life propagation, domestic water supply, agricultural water supply (i.e.,

irrigation and stock watering), commerce and industrial waters, and fish and wildlife propagation. The State of South Dakota has not placed Lake Oahe on the state's Section 303(d) list of impaired waters.

Lake Oahe filled to the bottom of the annual flood control zone (elevation 1607.5 feet) for the first time in 1967. After 1967, the lake fluctuated within about 10 feet of the bottom of this zone until the end of 1988, when the lake dropped to nearly 20 feet (or 6 MAF) below the base of the zone. At the peak of the 1987 to 1993 drought, the lake dropped an additional 10 feet to elevation 1581. In 1996 and 1997, the lake peaked at elevation 1618 feet. Lake Oahe fell below 1607.5 again in 2000 due to the current drought, and is currently near or below historic low water conditions. Water discharged through Oahe Dam is withdrawn from Lake Oahe at elevation 1540 – approximately 115 feet above the lake bottom.

19.2.3.2 2003 Water Quality Conditions

Appendix A.12 summarizes the water quality conditions that were monitored in Lake Oahe during 2003. A review of these results indicated no significant water quality concerns. The only water quality standards criteria exceeded at the in-lake site were water temperature and dissolved oxygen for the protection of coldwater permanent fish life propagation. Approximately 14% of the recorded temperature observations exceeded 18.3°C, with the maximum temperature recorded being 24.2°C. South Dakota's water quality standards' indicate 65°F (18.3°C) is the upper limit for supporting coldwater permanent fish life propagation. Five recorded dissolved oxygen measurement (i.e., 2.3% of the total measurements) were less than 7.0 mg/l – the lower limit identified by the South Dakota's water quality standards for the protection of spawning areas during the spawning season. No dissolved oxygen measurements were less than 6.0 mg/l – the level necessary to protect permanent coldwater fish life under non-spawning conditions.

Appendix A.13 summarizes the water quality conditions that were monitored in the tailwaters of Oahe Dam during 2003. A review of these results found that one water temperature measurement (i.e. 20%) and two total ammonia measurements (i.e., 40%) exceeded state water quality standards criteria. As noted above, water released through Oahe Dam is drawn out of the "mid-levels" of Lake Oahe (i.e., 115 feet above the lake bottom) and the temperature of the released water reflects the thermal stratification present in Lake Oahe. The two elevated total ammonia measurements in the tailwaters could indicate that the reduction of nitrogen compounds (i.e., nitrate-nitrites) is occurring in the lower depths of Lake Oahe where water is drawn for release through the dam.

19.2.3.3 Existing Summer Lake Temperature and Dissolved Oxygen Conditions

Existing summer thermal stratification and hypolimnetic dissolved oxygen conditions were determined for Lake Oahe based on monitoring results obtained during the past five years (i.e., 1999 to 2003) at the in-lake long-term fixed station monitoring site. Temperature and dissolved oxygen depth profiles were constructed from water quality data collected during the period May through September (Appendices A.14 and A.15). Appendix A.14 shows that significant temperature gradients did periodically exist in Lake Oahe during this period with a thermocline becoming established at a depth of about 25 meters. There appears to be no significant gradient in summer dissolved oxygen levels in lower Lake Oahe near the dam (Appendix A.15). Appendix A.15 indicates that at most depths and occasions, measured dissolved oxygen levels were above the 6 and 7 mg/l water quality standards criteria for protection of coldwater permanent fish life propagation as defined by South Dakota.

19.2.3.4 Existing Lake Trophic Conditions

TSI values for Lake Oahe were calculated from monitoring data collected during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring site. Table 11 summarizes the TSI values calculated for Lake Oahe. The TSI values seem to indicate that Lake Oahe is in a mesotrophic

trophic state. It is noted that the 5-year period 1999-2003 has been a period of extended drought in the area of Lake Oahe, and the drought conditions may have had an influence on the lake water quality parameters used to calculate the TSI values.

Table 11. Summary of Trophic State Index (TSI) Values Calculated for Lake Oahe for the 5-year Period 1999-2003.

TSI*	No. of Obs.	Mean	Median	Minimum	Maximum
TSI(SD)	18	38	37	32	47
TSI(Chl)	13	46	40	40	60
TSI(TP)	22	48	48	41	59
TSI(Avg)	11	44	44	39	50

* See text for explanation.

19.2.4 BIG BEND

19.2.4.1 Background Information

Big Bend Dam is located in central South Dakota 21 miles northwest of Chamberlain, South Dakota at river mile 987 of the Missouri River. The closing of Big Bend Dam in 1963 resulted in the formation of Lake Sharpe that is 80 miles long and covers 61,000 acres when full. The dam and lake are used for flood control, irrigation, navigation, hydropower, domestic and sanitary use, fish and wildlife, and recreation. Lake Sharpe is used as a water supply by the Cities of Pierre, Fort Pierre, Fort Thompson, and Lower Brule, South Dakota. The major inflows to Lake Sharpe are the Missouri River and Bad River.

Pursuant to the Federal Clean Water Act (CWA), the State of South Dakota has designated the following water quality-dependent beneficial uses for Lake Sharpe: recreation (i.e., immersion and limited-contact), coldwater permanent fish life propagation, domestic water supply, agricultural water supply (i.e., irrigation and stock watering), commerce and industrial waters, and fish and wildlife propagation. Big Bend Dam is the demarcation point between coldwater and warmwater use designation on the Missouri River system in South Dakota. Therefore, the designated use of warmwater permanent fish life propagation applies to the Big Bend Dam tailwaters instead of the coldwater permanent fish life propagation use that applies to Lake Sharpe. The State of South Dakota has delisted Lake Sharpe from the state's Section 303(d) list of impaired waters. The lake was previously listed as impaired due to accumulated sediment from the Bad River watershed. A total maximum daily load (TMDL) was developed and is being implemented to address this concern, resulting in the delisting of Lake Sharpe.

Generally, weekly flows from Oahe Dam are released at Big Bend Dam, and there is minimal fluctuation in the Lake Sharpe water level. There are no minimum flow requirements below Big Bend Dam. Hourly releases at Big Bend Dam fluctuate from 0 to 110 kcfs for peaking power generation. Water discharged through Big Bend Dam is withdrawn from the surface of Lake Sharpe via a head gate.

19.2.4.2 2003 Water Quality Conditions

Appendix A.16 summarizes the water quality conditions that were monitored in Lake Sharpe during 2003. A review of these results indicated that water temperature and dissolved oxygen might be water quality concerns. Based on the criteria for the protection of coldwater permanent fish life propagation, water temperature criteria were exceeded 77% of the time and dissolved oxygen criteria up to 29% of the time. It is noted that if the lake were classified for the protection of warmwater permanent fish propagation instead of coldwater, there would have been no exceedences of water quality criteria for either temperature or dissolved oxygen. It doesn't appear that ambient water temperatures in Lake Sharpe

are low enough to support coldwater permanent fish life propagation as defined by state water quality criteria. Consideration should be given to reclassify Lake Sharpe for a warmwater permanent fish life propagation use based on a use attainability assessment of "natural conditions" regarding ambient water temperature.

Appendix A.17 summarizes the water quality conditions that were monitored in the tailwaters of Big Bend Dam during 2003. A review of these results revealed no significant water quality concerns.

19.2.4.3 Existing Summer Lake Temperature and Dissolved Oxygen Conditions

Existing summer water temperature and dissolved oxygen conditions were determined for Lake Sharpe based on monitoring results obtained during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring site. Temperature and dissolved oxygen depth profiles were constructed from water quality data collected during the period May through September (Appendices A.18 and A.19). Appendices A.18 and A.19 show that significant temperature and dissolved oxygen gradients did not exist in Lake Sharpe during this period. The size of the lake, configuration of the outlet structure, and the release of water through Big Bend Dam for peaking power generation (i.e., up to 110,000 cfs), seemingly does not allow stratification to occur in Lake Sharpe.

19.2.4.4 Existing Lake Trophic Conditions

TSI values for Lake Sharpe were calculated from monitoring data collected during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring site. Table 12 summarizes the TSI values calculated for Lake Sharpe. The TSI values seem to indicate that Lake Sharpe is in a mesotrophic trophic state.

Table 12. Summary of Trophic State Index (TSI) Values Calculated for Lake Oahe for the 5-year Period 1999-2003.

TSI*	No. of Obs.	Mean	Median	Minimum	Maximum
TSI(SD)	17	47	47	37	59
TSI(Chl)	8	53	48	40	71
TSI(TP)	21	52	52	34	79
TSI(Avg)	5	50	48	42	56

* See text for explanation.

19.2.5 FORT RANDALL

19.2.5.1 Background Information

Fort Randall Dam is located in southeastern South Dakota 50 miles southwest of Mitchell, South Dakota at river mile 880 of the Missouri River. The closing of Fort Randall Dam in 1952 resulted in the formation of Lake Francis Case that is 107 miles long and covers 102,000 acres when full. The dam and lake are used for flood control, irrigation, navigation, hydropower, domestic and sanitary use, fish and wildlife, and recreation. Lake Francis Case is used as a water supply by the communities of Chamberlain, Dante, Geddes, Greenwood, Kimball, Lake Andes, Marty, Oacoma, Platte, Pickstown, Pukkwana, Ravinia, Reliance, Wagner, White Lake, South Dakota. Major inflows to the lake are the Missouri River and White River.

Pursuant to the Federal Clean Water Act (CWA), the State of South Dakota has designated the following water quality-dependent beneficial uses for Lake Francis Case: recreation (i.e., immersion and limited-contact), warmwater permanent fish life propagation, domestic water supply, agricultural water supply (i.e., irrigation and stock watering), commerce and industrial waters, and fish and wildlife

propagation. The State of South Dakota has not placed Lake Francis Case on the state's Section 303(d) list of impaired waters.

Lake Francis Case has filled into the annual flood control and multiple use zone (elevation 1350 to 1365 feet) each year since it was first filled in 1954. The water surface elevation normally varies throughout the year from about elevation 1337 to 1357 feet, while total storage varies from about 2.4 to 3.6 MAF. The greatest variability occurs during the fall draw down period. Water discharged through Fort Randall Dam is withdrawn from Lake Francis Case at elevation 1218 – approximately 11 feet above the lake bottom.

19.2.5.2 2003 Water Quality Conditions

Appendix A.20 summarizes the water quality conditions that were monitored in Lake Francis Case during 2003. A review of these results indicated three parameters (i.e., pH, dissolved oxygen, and total ammonia) apparently exceeded state water quality criteria. The pH criterion of not less than 6.5 was exceeded 27 times (i.e., 15% of the measurements). It is noted that all of these measurements were part of one depth profile taken in late September, and the possibility exists that measurement error may have occurred. The 6 exceedences of the 5.0 mg/l dissolved oxygen criterion also occurred during one depth profile that was taken in late August. On this occasion, low dissolved oxygen levels were measured in the bottom 6 meters (i.e., 30 to 36 meter depth) of the recorded profile. The one total ammonia value that exceeded the criterion did so just slightly.

Appendix A.21 summarizes the water quality conditions that were monitored in the tailwaters of Fort Randall Dam during 2003. A review of these results revealed no significant water quality concerns.

19.2.5.3 Existing Summer Lake Temperature and Dissolved Oxygen Conditions

Existing summer thermal stratification and hypolimnetic dissolved oxygen conditions were determined for Lake Francis Case based on monitoring results obtained during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring site. Temperature and dissolved oxygen depth profiles were constructed from water quality data collected during the period May through September (Appendices A.22 and A.23). Although the data collected over the past 5 years don't indicate the presence of a "strong" thermocline, it does indicate that a "weak" thermocline appears to set up at about 25 meters depth (Appendix A.22). Since the depth of the lake near the dam is approximately 35 meters, a thermocline at about 25 meters could allow for the establishment of a "small" hypolimnion. There occasionally appears to be a reduction in dissolved oxygen levels in the lower depths of the lake as indicated by the profile data collected over the past 5 years (Appendix A.23). Dissolved oxygen concentrations less than the state water quality standards criterion of 5.0 mg/l were measured on three different occasions.

19.2.5.4 Existing Lake Trophic Conditions

TSI values for Lake Francis Case were calculated from monitoring data collected during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring site. Table 13 summarizes the TSI values calculated for Lake Francis Case. The TSI values seem to indicate that the lake is in a mesotrophic trophic state; however, total phosphorus levels may indicate that it is moving into a slightly eutrophic state.

Table 13. Summary of Trophic State Index (TSI) Values Calculated for Lake Francis Case for the 5-year Period 1999-2003.

TSI*	No. of Obs.	Mean	Median	Minimum	Maximum
TSI(SD)	16	44	44	35	56
TSI(Chl)	10	45	41	33	75
TSI(TP)	14	52	53	34	65
TSI(Avg)	9	45	45	38	55

* See text for explanation.

19.2.6 GAVINS POINT

19.2.6.1 Background Information

Gavins Point Dam is located in southeast South Dakota, on the South Dakota-Nebraska border, 4 miles west of Yankton, South Dakota at river mile 811 of the Missouri River. The closing of Gavins Point Dam in 1955 resulted in the formation of the Lewis and Clark Lake that is 25 miles long and covers 31,000 acres when full. The lake and dam are used for flood control, irrigation, navigation, hydropower, domestic and sanitary use, fish and wildlife, and recreation. Lewis and Clark Lake is used as a water supply by the Cities of Yankton, Bon Homme, Springfield, and Cedar, South Dakota. Major inflows to the lake are the Missouri River and Niobrara River.

Pursuant to the Federal Clean Water Act (CWA), the State of South Dakota has designated the following water quality-dependent beneficial uses for Lewis and Clark Lake: recreation (i.e., immersion and limited-contact), warmwater permanent fish life propagation, domestic water supply, agricultural water supply (i.e., irrigation and stock watering), commerce and industrial waters, and fish and wildlife propagation. The State of Nebraska has designated the following beneficial uses to Lewis and Clark Lake: primary contact recreation, Class I warmwater aquatic life, drinking water supply, agricultural water supply, industrial water supply, and aesthetics. The uses designated by the States of South Dakota and Nebraska to Lewis and Clark Lake are consistent with each other. Neither of the States of South Dakota or Nebraska has placed Lewis and Clark Lake on the state's Section 303(d) list of impaired waters.

Lewis and Clark Lake water elevation and storage levels vary little within and between years. The water level is drawn down from elevation 1207 feet toward the base of the annual flood control and multiple use zone (elevation 1204.5 feet) each spring and the lake is allowed to fill before fall into the flood control and multiple use zone. The lake is operated at elevation 1206 feet during the tern and plover nesting season, and it is allowed to rise to elevation 1207 feet just before each fall. Water discharged through Gavins Point Dam is withdrawn from the surface of Lewis and Clark Lake via a head gate.

19.2.6.2 2003 Water Quality Conditions

Appendices A.24 and A.25 respectively summarize water quality conditions that were monitored in Lewis and Clark Lake and the tailwaters of Gavins Point Dam during 2003. A review of these results indicated no water quality concerns, as none of the monitored parameters exceeded state water quality criteria.

19.2.6.3 Existing Summer Lake Temperature and Dissolved Oxygen Conditions

Existing summer water temperature and dissolved oxygen conditions were determined for Lewis and Clark Lake based on monitoring results obtained during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring site. Temperature and dissolved oxygen depth profiles were

constructed from water quality data collected during the period May through September (Appendices A.26 and A.27). Appendix A.26 indicates that a "strong" thermocline does not seem to become established during the summer in the lake; however, a slight temperature gradient is occasionally present. A significant decreasing gradient of dissolved oxygen concentrations with depth does occur in the lake during the summer. Dissolved oxygen concentrations below 5.0 mg/l were measured near the bottom. It appears that although the temperature gradient is "slight" it results in enough of a density difference to limit mixing within the water column and the re-oxygenation of deeper water. This can be seen in Appendices A.26 and A.27 where the solid lines represent temperature and dissolved oxygen profiles measured at the same time. In those cases where a significant dissolved oxygen gradient existed there was an observable slight temperature gradient.

19.2.6.4 Existing Lake Trophic Conditions

TSI values for Lewis and Clark Lake were calculated from monitoring data collected during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring site. Table 14 summarizes the TSI values calculated for the lake. The TSI values seem to indicate that Lewis and Clark Lake is in a eutrophic state.

Table 14. Summary of Trophic State Index (TSI) Values Calculated for Lewis and Clark Lake for the 5-year Period 1999-2003.

TSI*	No. of Obs.	Mean	Median	Minimum	Maximum
TSI(SD)	24	61	62	50	70
TSI(Chl)	11	58	59	33	69
TSI(TP)	24	53	56	34	71
TSI(Avg)	11	58	57	52	66

* See text for explanation.

19.2.7 SUMMARY OF HYPOLIMNETIC CONDITIONS AND TROPHIC STATUS OF THE MISSOURI RIVER MAINSTEM RESERVOIRS

Table 15 summarizes the hypolimnetic conditions and trophic status of the six Missouri River mainstem reservoirs based on monitoring data collected over the 5-year period 1999 to 2003.

Table 15. Hypolimnetic and Trophic Conditions Determined for the Six Missouri River Mainstem Reservoirs during the Period 1999 to 2003.

	Fort Peck Lake	Lake Sakakawea	Lake Oahe	Lake Sharpe	Lake Francis Case	Lewis and Clark Lake
Extent of Hypolimnion	Large	Large	Large	None	Small	Very Small
Low Dissolved Oxygen Concerns in Hypolimnion	No	Yes	No	No	Yes	Yes
Lake Trophic Status*	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Eutrophic
Average TSI Score**	51	43***	45	46	47	59

* Based on near dam water quality conditions.
** TSI = Trophic State Index (see text for explanation).
*** Significant longitudinal variation exists from the dam to the inflow of the Missouri River based on data collected in 2003.

19.2.8 LOWER MISSOURI RIVER – FORT RANDALL DAM TO RULO, NEBRASKA

19.2.8.1 Background Information

The 39-mile "natural-channel" reach of the Missouri River from Fort Randall Dam to the headwaters of Lewis and Clark Lake and the 59-mile "natural-channel" reach from Gavins Point Dam to

Ponca State Park, Nebraska have been designated as National Recreational Rivers under the Federal Wild and Scenic Rivers Act (WSRA). The National Park Service (NPS) manages the 39-mile reach pursuant to the WSRA, while the NPS and Corps jointly manage the lower 59-mile reach under the WSRA. The justification that supported that these reaches of the Missouri River be protected as recreational rivers identified their outstanding remarkable recreational, fish and wildlife, aesthetic, historical, and cultural values. Under the WSRA, the U.S. Department of Interior (i.e., NPS) is mandated to administer these reaches in a manner that will protect and enhance these values for the benefit and enjoyment of present and future generations.

The 255-mile reach of the Missouri River from Ponca State Park to the Omaha District Boundary near Rulo, Nebraska is managed by the Corps under the Missouri River Bank Stabilization and Navigation Project. In addition to the primary authorization to maintain a 9-foot-deep by 300-foot-wide navigation channel downstream from Sioux City, Iowa, there are authorizations to stabilize the river's banks. This reach of the river has been modified over its entire length by an intricate system of dikes and revetments designed to provide a continuous navigation channel without the use of locks and dams.

Pursuant to the Federal Clean Water Act (CWA), the States of South Dakota, Nebraska, Iowa, and Missouri have designated water quality-dependent beneficial uses, in their state water quality standards, for appropriate reaches of the "free-flowing" Missouri River downstream of Fort Randall Dam. South Dakota has designated the following uses for all of the Missouri River within the state downstream of Fort Randall Dam: primary contact recreation, warmwater fishery, drinking water supply, and industrial water supply. Nebraska has designated the following uses to the entire length of the Missouri River in Nebraska: primary contact recreation, warmwater aquatic life, agricultural water supply, and aesthetics. It has designated the use of drinking water supply to the river below the confluence of the Niobrara River, and industrial water supply to the river below the confluence of the Big Sioux River. Nebraska has also designated the reaches between the Nebraska-South Dakota border and Lewis and Clark Lake and between Gavins Point Dam and Ponca State Park as Outstanding State Resource Waters for protection under the state water quality standard's antidegradation policy. Iowa has designated the following uses to all of the Missouri River in the state: primary contact recreation, warmwater fishery, and high quality state resource water. It has also designated the use of drinking water supply to the river in the area of Council Bluffs, Iowa. Missouri has designated the following uses to all of the river: primary contact recreation, warmwater fishery, drinking water supply, agricultural water supply, and industrial water supply. The States of Nebraska, Iowa, and Missouri have listed the Missouri River on their state's Section 303(d) list of impaired waters. The pollutant/stressors identified are pathogens, siltation, and habitat loss. The source of siltation and habitat loss is identified as hydrologic modifications and channelization. The identified sources for the pathogens are municipal point sources, agriculture, and urban runoff.

Releases from Gavins point Dam follow the same pattern as those from Fort Randall Dam because there is little active storage in Lewis and Clark Lake. Releases from both dams are based on the amount of water in system storage, which governs how much water will be released to meet service demands in the portion of the lower Missouri River from Sioux City to St. Louis. Constraints for flood control, threatened and endangered bird nesting, and fish spawning requirements also are factors governing releases. Releases from Gavins Point Dam generally fall into three categories: navigation, flood evacuation, and nonnavigation releases. In the navigation season, which generally runs from April 1 through December 1 at the mouth, releases from Gavins Point Dam are generally 25 to 35 kcfs. In the winter, releases are in the 10- to 20- kcfs range. In wet years with above-normal upstream inflows, releases are higher to evacuate flood control storage space in upstream reservoirs. Maximum winter releases are generally kept below 24 kcfs to minimize downstream flooding problems caused by ice jams in the lower river. During the 1987 to 1993 drought, nonnavigation releases were generally in the 8- to 9-kcfs range immediately following the end and preceding the start of the navigation season. During cold weather, releases were increased up to 15 kcfs, but generally averaged 12 kcfs over the 3-month winter

period from December through February. In more recent years, winter releases have averaged from 25 kcfs to as high as 30 kcfs for flood storage evacuation.

19.2.8.2 2003 Water Quality Conditions

Nine sites on the Missouri River below Fort Randall Dam were monitored during 2003 (Figure 2). Water quality conditions at two of these monitoring sites, Fort Randall Dam tailwaters and Gavins Point Dam tailwaters, were previously discussed (see Appendices A.21 and A.25). Appendices A.28 - A34 summarize water quality conditions that were monitored at the seven other sites. A review of these results revealed that the water quality standards criteria for three parameters (i.e., pH, suspended solids, and atrazine) were exceeded. The pH criteria were exceeded one time at site RM851. The suspended solids criterion was exceed two times at site RM774 and three times at RM753. The atrazine chronic criterion was exceeded one time RM619.

Appendix A.35 plots the distribution of measured parameter values as box plots at each of the nine monitoring sites. For comparison purposes, the box plots for the monitoring sites are arranged relative to their respective location from upstream to downstream (i.e., RM880, RM851, RM811, RM774, RM753, RM691, RM619, RM563, and RM498). As shown in Appendix 35, flow, water temperature, turbidity, total suspended solids, chemical oxygen demand, nitrate-nitrite nitrogen, total phosphorus, chlorides, and atrazine appeared to substantially increase in a downstream direction.

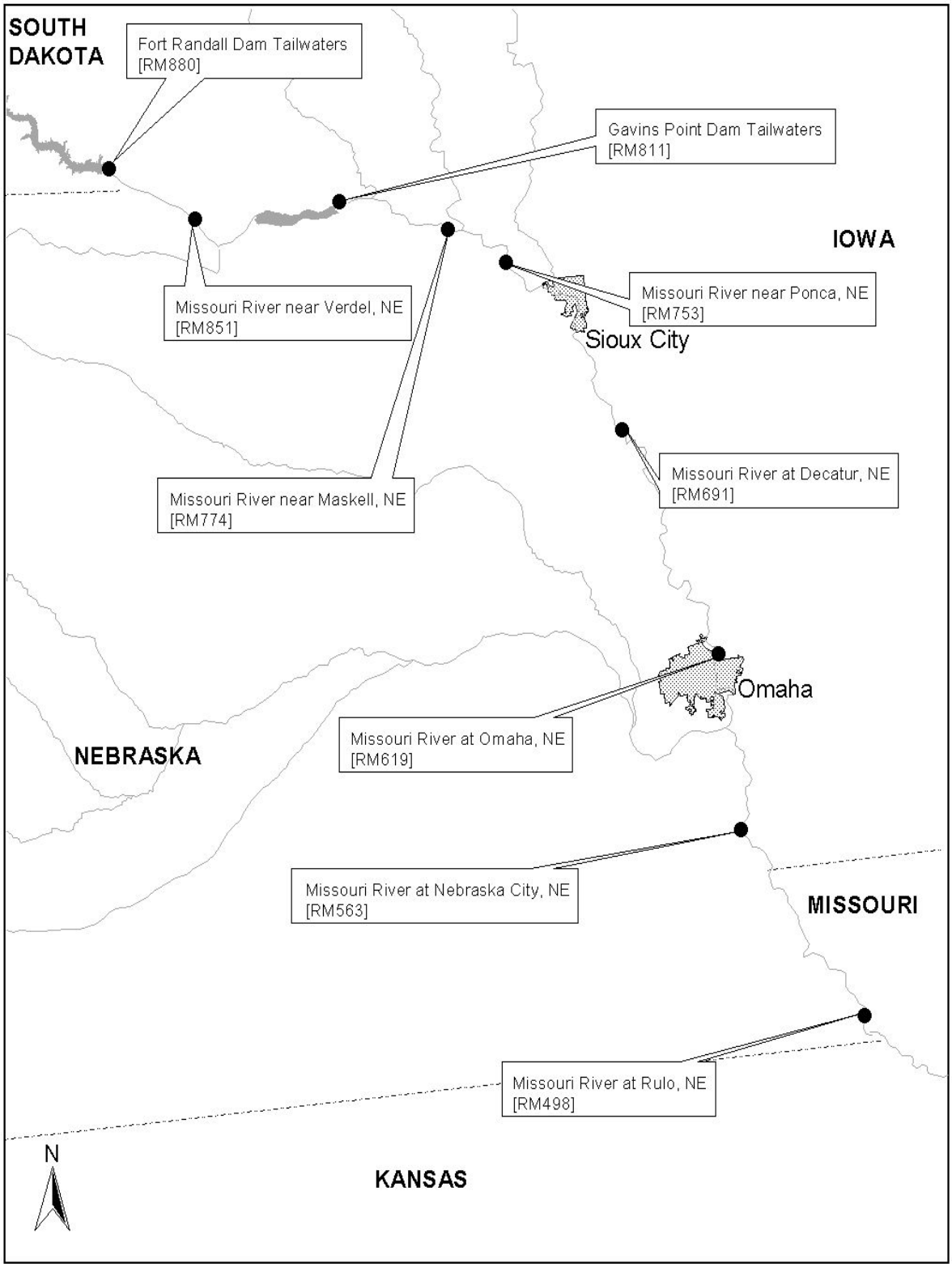


Figure 2. Missouri River Sites, from Fort Randall Dam to Rulo, Nebraska, that were monitored for water quality during 2003.

19.3 TRIBUTARY PROJECTS

Omaha District tributary projects include Corps dams, and their associated lakes, that are located on rivers and streams that are tributaries to the Missouri River. Table 16 lists the tributary projects, by state, in the Omaha District. Water quality monitoring occurred at all the tributary projects during 2003. The Omaha District conducted water quality monitoring at all the tributary projects except those in Colorado – water quality monitoring at the Colorado tributary projects was conducted by estblished local Watershed Authorities. The water quality monitoring targeted at the tributary projects by the Omaha District in 2003 was to continue the long-term fixed station monitoring at previously established monitoring locations. The long-term fixed station monitoring was to consist of: 1) monthly (i.e., May through September) field measurements and sample collection at the previously monitored in-lake locations, and 2) inflow sampling under runoff conditions. Table 17 lists the field measurements and sample analyses that were targeted for the in-lake and inflow monitoring.

Table 16. Tributary Projects in the Omaha District.

Project Name	General Location	Date of Dam Closure	Lake Size (Acres)
Colorado – Tri-Lakes:			
Bear Creek Lake	Denver, CO	1977	107
Chatfield Lake	Denver, CO	1973	1,423
Cherry Creek Lake	Denver, CO	1948	844
Nebraska – Salt Creek Lakes:			
Olive Creek Lake	Lincoln, NE	1963	162
Bluestem Lake	Lincoln, NE	1962	309
Wagon Train Lake	Lincoln, NE	1962	277
Stagecoach Lake	Lincoln, NE	1963	195
Yankee Hill Lake	Lincoln, NE	1965	211
Conestoga Lake	Lincoln, NE	1963	217
Twin Lakes (East and West Twin Lakes)	Lincoln, NE	1965	236
Pawnee Lake	Lincoln, NE	1964	739
Holmes Lake	Lincoln, NE	1962	123
Branched Oak Lake	Lincoln, NE	1967	1,847
NEBRASKA – PAPILLION CREEK LAKES:			
Glenn Cunningham Lake	Omaha, NE	1974	377
Standing Bear Lake	Omaha, NE	1972	125
Ed Zorinsky Lake	Omaha, NE	1984	259
Wehrspann Lake	Omaha, NE	1982	239
NORTH DAKOTA LAKES:			
Bowman-Haley Lake	Bowman, ND	1966	1,732
Pipestem Lake	Jamestown, ND	1973	840
SOUTH DAKOTA LAKES:			
Cold Brook Lake	Hot Springs, SD	1952	36
Cottonwood Springs Lake	Hot Springs, SD	1969	41

Table 17. Targeted Water Quality Monitoring at In-Lake and Inflow Long-Term Fixed Station Tributary Sites.

Parameter	In-Lake Sites			Inflow Runoff
	Near-Dam, Deepwater			
	Near Surface*	Near Bottom*	Mid-Lake	
Total Suspended Solids	X	X		X
Total Kjeldahl Nitrogen	X	X		X
Nitrate/Nitrite Nitrogen	X	X		X
Total Ammonia Nitrogen	X	X		
Total Phosphorus	X	X		X
Dissolved Orthophosphorus	X	X		
Alkalinity	X	X		
Total Organic Carbon	X			
Chemical Oxygen Demand				
Chlorophyll *a*	X			
Pesticides				
• Complete Scan (May) **	X			
• Rapid Assay (immunoassay)***	X			X
Metals****	X			
Water Transparency (Secchi Depth)	X		X	
Profile*****	X		X	

* Near-surface sample collected at ½ the Secchi disk depth and the hypolimnetic sample is collected at approximately 1 meter above the lake bottom.

** One complete pesticide scan in May. The complete pesticide scan includes: acetochlor, alachlor, atrazine, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, pebulate, pendimenthalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin and vernolate.

*** Rapid Assay (immunoassay) for atrazine, alachlor, and metolachlor at all times.

**** Only analyzed for in the month of August. Dissolved metals to be analyzed: Ag, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Ti, and Zn. Total metals to be analyzed Hg and Se. Hardness will also be calculated from Ca and Mg concentrations.

***** Profile measurements are taken every ½-meter from the surface to bottom. Measurements to be taken include: temperature, dissolved oxygen, pH, conductivity, and ORP.

19.3.1 COLORADO TRIBUTARY PROJECTS

19.3.1.1 Background Information

Three tributary projects are located in Colorado within the Omaha District: Bear Creek Lake, Chatfield Lake, and Cherry Creek Lake (Table 16). All three lakes are located in the Denver, Colorado metropolitan area. Bear Creek Dam is located on Bear Creek in the southwest Denver metropolitan area near Lakewood, Colorado. Chatfield Dam is located on the South Platte River in the south Denver metropolitan area near Littleton, Colorado. Cherry Creek Dam is located on Cherry Creek in the southwest Denver metropolitan area near Aurora, Colorado. The authorized project purposes for Bear Creek Lake are: flood control, recreation, and fish and wildlife management. The authorized project purposes for Chatfield Lake are: flood control, irrigation, municipal water supply, recreation, and fish and wildlife management. The authorized project purposes for Cherry Creek Lake are: flood control, irrigation, navigation, municipal water supply, recreation, and fish and wildlife management.

The State of Colorado's water quality standards designate the following beneficial uses to all three tributary project lakes: primary contact recreation, domestic water supply, and agriculture. Bear

Creek Lake and Chatfield Lake are designated a Class 1 coldwater aquatic life use, and Cherry Creek is designated a Class 1 warmwater aquatic life use. Currently, only Chatfield Lake is used as a public drinking water supply (i.e., Denver, Englewood, and Littleton, Colorado). Due to the current drought conditions, Chatfield Lake may be largely drained in the coming year to meet the public water supply needs of the Denver metropolitan area.

Pursuant to Section 303(d) of the CWA, the State of Colorado has placed Cherry Creek Lake on the state's 303(d) list of impaired waters citing impairment to the uses of aquatic life and primary contact recreation due to elevated chlorophyll *a* levels resulting from high phosphorus loadings to the lake.

19.3.1.2 2003 Water Quality Conditions

Water quality data for 2003 were not available for the Colorado Tributary Lakes at the time this report was prepared.

19.3.2 NEBRASKA TRIBUTARY PROJECTS

19.3.2.1 Background Information

Omaha District tributary projects in Nebraska occur in two primary watersheds in the southeast area of the State: Salt Creek watershed in the Lincoln, Nebraska area and Papillion Creek watershed in the Omaha, Nebraska area. Eleven project lakes are located in the Salt Creek watershed: Olive Creek Lake, Bluestem Lake, Wagon Train Lake, Stagecoach Lake, Yankee Hill Lake, Conestoga Lake, East Twin Lake, West Twin Lake, Pawnee Lake, Holmes Lake, and Branched Oak Lake (Table 16). Four project lakes are located in the Papillion Creek watershed: Glenn Cunningham Lake, Standing Bear Lake, Ed Zorinsky Lake, and Wehrspann Lake. The authorized purposes for all the project lakes are flood control, recreation, and fish and wildlife management. Yankee Hill and Holmes Lakes are currently severely drawn down to facilitate lake renovation work.

The State of Nebraska's water quality standards designates the following beneficial uses to all the Salt Creek and Papillion Creek tributary project lakes: recreation, warmwater aquatic life, agricultural water supply, and aesthetics. None of these lakes are used as a public drinking water supply. Designated swimming beaches are present at Branched Oak Lake, Pawnee Lake, and Bluestem Lake.

Pursuant to the CWA, the State of Nebraska has placed all the Salt Creek and Papillion Creek watershed lakes on the state's Section 303(d) list of impaired waters citing impairment to the uses of aquatic life and aesthetics. The identified pollutant/stressors include: nutrients, sedimentation, and low dissolved oxygen from point and nonpoint source pollution. The State of Nebraska has issued fish consumption advisories for Ed Zorinsky and Wehrspann Lakes due to mercury concerns.

19.3.2.2 2003 Water Quality Conditions

Appendices B.1 through B.13 summarize water quality conditions that were monitored in the Nebraska Tributary Reservoirs during 2003. When considering the water quality standards attainment statistics in Appendices B.1 - B.13 it should be noted that Nebraska's water quality standards state the following:

> *"In lakes and impoundments, or portions thereof, which exhibit natural thermal stratification, all applicable narrative and numerical criteria, with the exception of the numerical criteria for temperature, apply only to the epilimnion".*

The state water quality standards exceedences listed in Appendices B.1 - B.13 are based on all measurement taken in the respective lakes and don't consider any natural thermal stratification that may

have been present. Natural thermal stratification does occur on many of the Nebraska Tributary Lakes, but it tends to be intermittent due to the relative shallowness of the lakes. Also, it should be noted that Nebraska's chronic criteria for aquatic life are generally based on 4-day average concentrations and are not directly comparable to "instantaneous" measurements (i.e., single "grab-type" samples). The comparison of the collected data to chronic criteria is presented for relative interpretation.

The parameter that exceeded water quality standards criteria most often was dissolved oxygen. Low dissolved oxygen levels occurred at all the lakes. All of the dissolved oxygen concentrations below 5.0 mg/l were recorded in the lower portions of the depth profiles taken. The low dissolved oxygen levels in the "deeper" water are believed associated to a significant degree with thermal stratification of the lake. Many, if not most, of the dissolved oxygen concentrations measured below 5.0 mg/l may have been below the "epilimnion" and not applicable to the 5.0 mg/l dissolved oxygen criteria.

A review of Appendices B.1 - B.13 indicates that water quality standards criteria for pH probably were exceeded at Conestoga, Ed Zorinsky, Glenn Cunningham, Olive Creek, and Wagon Train Lakes. All of these exceedences involved measured pH levels being above 9.0. The situation at Olive Creek Lake appears significant, as 59% (i.e., 22 of 37 measurements) were above 9.0 with the maximum pH recorded being 10.2. The high pH levels present in Olive Creek Lake are believed to be due to the extensive algal blooms that occurred in the lake and the uptake of carbon dioxide (CO_2) through photosynthesis. There is an inverse relationship between pH and CO_2. When aquatic plants (plankton or macrophytes) remove CO_2 from the water to form organic matter through photosynthesis, the pH increases. The Nebraska Tributary Lakes tend to be weakly buffered systems with low alkalinities. Weakly buffered systems with low alkalinities (i.e., <500 mg/l alkalinity) experience larger shifts in pH than well-buffered systems (i.e., >1,000 mg/l alkalinity). It is noted that the three lakes with highest percent exceedence of the pH criteria also had the three highest maximum chlorophyll *a* concentrations. It should also be noted that higher pH levels increase the relative toxicity of "total ammonia" as more will be in the un-ionized state (i.e., as pH increases the total ammonia criteria for the protection of aquatic life decreases). This may have contributed to the two instances where the total ammonia criterion was exceeded (i.e., Ed Zorinsky and Olive Creek Lakes).

As shown in Appendices B.1 – B.13, one measurement for arsenic (Olive Creek Lake), cadmium (Ed Zorinsky Lake), lead (Stagecoach Lake), selenium (Pawnee Lake), and atrazine (Olive Creek) were above the chronic criteria for the protection of aquatic life. The only one of these parameters that is believed to be a concern at this time is atrazine. Although only one measurement potentially exceeded the chronic criteria for aquatic life protection, it is noted that atrazine was detected in all the lakes all of the time. There appears to be a "residual" level of atrazine present in all the Nebraska Tributary lakes. This is attributed to the dominance of the agricultural land use (i.e., especially corn production) in the lakes watersheds.

19.3.2.3 Existing Lake Trophic Conditions

TSI values for the Nebraska Tributary Lakes were calculated from monitoring data collected during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring sites. Table 18 summarizes the TSI values calculated for the lakes. The TSI values indicate that all of the lakes are in or near a Hypereutrophic state. Olive Creek and West Twin Lakes appear to be in the worst trophic state and Ed Zorinsky Lake in the best. All of the lakes appear to be subject to accelerated eutrophication due to high phosphorus loads being delivered to the lakes from their watersheds and the internal cycling of phosphorus within the lakes. It is noted that all of the Nebraska Tributary Lakes are on Nebraska's 303(d) list of impaired waters for nutrient enrichment.

Table 18. Mean Trophic State Index (TSI) Values Calculated for Nebraska Tributary Lakes Based on Water Quality Data Collected during the Period 1999 to 2003. (See text for an explanation of TSI.)

Lake	Mean Trophic State Index (TSI) Value			
	TSI Secchi Depth	TSI Total Phosphorus	TSI Chlorophyll *a*	TSI Average
Bluestem Lake	80	71	62	71
Branched Oak Lake	71	63	71	69
Conestoga Lake	68	68	76	71
East Twin Lake	72	62	72	69
Ed Zorinsky Lake	64	61	67	63
Glenn Cunningham Lake	72	64	70	68
Olive Creek Lake	78	73	78	77
Pawnee Lake	69	64	74	69
Standing Bear Lake	68	57	70	65
Stagecoach Lake	74	74	71	73
Wagon Train Lake	66	72	73	70
Wehrspann Lake	69	65	77	70
West Twin Lake	85	73	74	77

19.3.3 NORTH DAKOTA TRIBUTARY LAKES

19.3.3.1 Background Information

Two tributary projects are located in North Dakota within the Omaha District: Bowman-Haley Lake and Pipestem Lake (Table 16). Bowman-Haley Lake is located in southwest North Dakota along the South Dakota border. The dam is on the North Fork of the Grand River, 6 miles west of Haley, North Dakota. The authorized project purposes of Bowman-Haley Lake are flood control, municipal and industrial water supply, recreation, and fish and wildlife management Pipestem Lake is located in southeast North Dakota. The dam is located on Pipestem Creek, 3 miles northwest of Jamestown, North Dakota. The authorized project purposes of Pipestem Lake are flood control, recreation, and fish and wildlife management.

The State of North Dakota has designated Bowman-Haley and Pipestem Lakes as Class 3 lakes in the state's water quality standards. The beneficial uses designated for class I streams are also applicable to all classified lakes in North Dakota. As such, the beneficial uses designated for Bowman-Haley and Pipestem Lakes are: primary contact recreation, warmwater fishery, wildlife, and agricultural water supply. Water quality is also to be suitable for municipal or domestic use after appropriate treatment. Neither lake is directly used as a municipal or domestic water supply.

19.3.3.2 2003 Water Quality Conditions

Appendices C.1 and C.2 respectively summarize the water quality conditions that were monitored in Bowman-Haley and Pipestem Lakes during 2003. Dissolved oxygen and phosphorus water quality criteria were exceeded in both lakes. The lower dissolved oxygen concentrations in both lakes were measured in the deeper part of the depth profile, and appeared to be associated with a temperature gradient within the lakes that occurred during the summer. When the low dissolved oxygen levels were measured, a large part of both the lakes had dissolved oxygen concentrations above 5.0 mg/l. A significant dissolved oxygen depth gradient was measured in mid-July at Pipestone Lake – dissolved oxygen concentrations were above 9.0 mg/l from the surface to 3.0 meters, 5.0 mg/l at 3.5 meters depth, and near or below 1.0 mg/l from a depth of 4 meters to the lake bottom at 10 meters. The total phosphorus water quality criterion of 0.1 mg/l was exceeded 100% of the time in Pipestone Lake; however, it is noted that the total phosphorus criterion is an interim guideline limit.

19.3.3.3 Existing Lake Trophic Conditions

TSI values for Bowman-Haley and Pipestem Lakes were calculated from monitoring data collected during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring sites. Table 19 summarizes the calculated TSI values for both lakes. The monitored conditions seem to indicate that Bowman-Haley is in a eutrophic state, and that Pipestem Lake is in a hypereutrophic state.

Table 19. Mean Trophic State Index (TSI) Values Calculated for North Dakota Tributary Lakes Based on Water Quality Data Collected during the Period 1999 to 2003. (See text for an explanation of TSI.)

Lake	Mean Trophic State Index (TSI) Value			
	TSI Secchi Depth	TSI Total Phosphorus	TSI Chlorophyll *a*	TSI Average
Bowman-Haley Lake	59	61	65	63
Pipestem Lake	57	77	63	68

19.3.4 SOUTH DAKOTA TRIBUTARY PROJECTS

19.3.4.1 Background Information

Two tributary projects are located in South Dakota within the Omaha District: Cold Brook Lake and Cottonwood Springs Lake (Table 16). Both lakes are located in southwest South Dakota in the Hot Springs, South Dakota area. Cold Book Dam is located on Cold Brook approximately 1-mile upstream from its confluence with the Fall River, and 2 miles north of Hot Springs, South Dakota. Cottonwood Springs Dam is located on Cottonwood Springs Creek approximately 5 miles west of Hot Springs South Dakota. The authorized project purposes for both projects are flood control, recreation, and fish and wildlife management.

As identified in the State of South Dakota's water quality standards, the following beneficial uses are designated for both Cold Brook and Cottonwood Springs Lakes: recreation (immersion and limited contact), fish and wildlife propagation, stock watering, and domestic water supply. Cold Brook is designated a coldwater permanent fish life propagation use, and Cottonwood Springs is designated a warmwater permanent fish life propagation use.

19.3.4.2 2003 Water Quality Conditions

Appendices D.1 and D.2 respectively summarize the water quality conditions that were monitored in Cold Brook and Cottonwood Springs Lakes during 2003. A review of these results indicated that water temperature might be a water quality concern in Cold Brook Lake. Based on the criteria for the protection of coldwater permanent fish life propagation, water temperature criteria were exceeded 77% of the time. It is noted that if the lake were classified for the protection of coldwater marginal fish life propagation or warmwater permanent fish life propagation instead of coldwater permanent fish life propagation, there would have been 32% exceedence of the marginal coldwater criterion of 23.8° C and no exceedences of the warmwater temperature criterion of 26.7° C. The ambient water temperatures in Cold Brook Lake may not be low enough to support coldwater permanent fish life propagation as defined by state water quality criteria. Consideration should be given to reclassify Cold Brook Lake for either a coldwater marginal life propagation or a warmwater permanent fish life propagation use based on a use attainability assessment of "natural conditions" regarding ambient water temperature. Dissolved oxygen criteria were exceeded in both Cold Brook and Cottonwood Springs Lakes. The lower dissolved oxygen concentrations in both lakes occurred in the deeper part of the measured depth profile and were associated

with a temperature gradient. The lower dissolved oxygen concentrations in the deeper water of Cold Brook Lake may be a concern if a coldwater fishery is to be supported. Water temperatures appear marginal in Cold Brook Lake for supporting a coldwater fishery, and the colder water that occurs in the lake is in the deeper portions where the lower dissolved oxygen levels occur.

19.3.4.3 Existing Lake Trophic Conditions

TSI values for the South Dakota Tributary Lakes were calculated from monitoring data collected during the past five years (i.e., 1999 to 2003) at the in-lake, long-term fixed station monitoring sites. Table 20 summarizes the TSI values calculated for Cold Brook and Cottonwood Springs Lakes. Both lakes appear to be in a mesotrophic state.

Table 20. Mean Trophic State Index (TSI) Values Calculated for South Dakota Tributary Lakes Based on Water Quality Data Collected during the Period 1999 to 2003. (See text for an explanation of TSI.)

Lake	Mean Trophic State Index (TSI) Value			
	TSI Secchi Depth	**TSI Total Phosphorus**	**TSI Chlorophyll *a***	**TSI Average**
Cold Brook Lake	33	49	53	46
Cottonwood Springs Lake	35	45	45	41

REFERENCES

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography, March 1977, Vol 22(2), pp. 361-369.

Houston Engineering, Inc. 2003. Final Lake Sakakawea analysis of cold water fish habitat. Prepared for Division of Water Quality, Environmental Health Section, North Dakota Department of Health.

U.S. Army Corps of Engineers. 1987. Engineer Manual (EM) 1110-2-1201, Reservoir water quality analysis. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

_____. 1995. Engineer Regulation (ER) 1110-2-8154, Engineering and design – Water quality and environmental management for Corps civil works projects. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.

_____. 2002. Quality management plan. Hydrologic Engineering Branch, Omaha District, U.S. Army Corps of Engineers, Omaha NE.

_____. 2003a. Strategic plan and guidance for implementing the Omaha District's water quality management program. December 2003. Water Quality Unit, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division, Omaha District, U.S. Army Corps of Engineers. Omaha, NE.

_____. 2003b. 2003 Program Management Plan for the Omaha District's Water Quality Management Program. April 2003. Water Quality Unit, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division, Omaha District, U.S. Army Corps of Engineers. Omaha, NE.

_____. 2003c. Framework for Monitoring Water Quality at the Missouri River Mainstem Reservoir Projects in the Omaha District. March 2003. Water Quality Unit, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division, Omaha District, U.S. Army Corps of Engineers. Omaha, NE.

_____. 2003d. Sampling and Analysis Plan for 2003 Monitoring of Omaha District Reservoirs in Nebraska. Water Quality Unit, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division, Omaha District, U.S. Army Corps of Engineers. Omaha, NE.

_____. 2003e. Sampling and Analysis Plan for 2003 Monitoring of the Missouri River in Nebraska. Water Quality Unit, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division, Omaha District, U.S. Army Corps of Engineers. Omaha, NE.

_____. 2003f. Sampling and Analysis Plan for 2003 Monitoring of Omaha District USACE Tributary Reservoirs in North and South Dakota. Water Quality Unit, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division, Omaha District, U.S. Army Corps of Engineers. Omaha, NE.

U.S. Army Corps of Engineers. 2003g. Sampling and Analysis Plan for 2003 Ambient Monitoring of the Missouri River Mainstem Reservoirs. Water Quality Unit, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division, Omaha District, U.S. Army Corps of Engineers. Omaha, NE.

_____. 2003h. Sampling and Analysis Plan for 2003 Lake Sakakawea Intensive Survey. Water Quality Unit, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division, Omaha District, U.S. Army Corps of Engineers. Omaha, NE.

APPENDICES

Appendix A. Water Quality Conditions Monitored at the Missouri Mainstem Projects.

Appendix B. Water Quality Conditions Monitored at the Nebraska Tributary Projects.

Appendix C. Water Quality Conditions Monitored at the North Dakota Tributary Projects.

Appendix D. Water Quality Conditions Monitored at the South Dakota Tributary Projects.

Appendix A.1. Summary of Water Quality Conditions Monitored in Fort Peck Lake at the Deepwater, Near-dam Location during June-September, 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	0.1	147	12.2	11.2	5.6	20.5	≤ 19.4	18	12.2%
Dissolved Oxygen (mg/l)	0.1	147	9.0	9.0	4.6	11.8	≥ 5.0	1	0.7%
Dissolved Oxygen (% Sat.)	0.1	147	87.5	92.7	44.6	102.2	-----	-----	-----
Specific Conductance (umho/cm)	1	147	552	543	531	577	-----	-----	-----
pH (S.U.)	0.1	147	-----	8.25	7.8	8.5	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	119	1.6	1.3	0.4	9.5	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	45	384	386	376	392	-----	-----	-----
Secchi Depth (in.)	1	2	198	198	180	216	-----	-----	-----
Alkalinity, Total (mg/l)	7	10	160	163	144	168	-----	-----	-----
Ammonia, Total (mg/l)	0.01	9	-----	0.07	n.d.	0.51	1.5[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	-----	0.14	n.d.	0.7	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	0.04	-----	-----	-----
Hardness, Total (mg/l)	0.4	6	220	210	203	262	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	-----	0.03	n.d.	0.08	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	10	-----	n.d.	n.d	0.02	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	-----	n.d.	n.d.	n.d.	-----	-----	-----
Chemical Oxygen Demand ((mg/l)	2	2	3.5	3.5	3	4	-----	-----	-----
Total Organic Carbon (mg/l)	0.05	6	2.7	2.6	2.3	3.0	-----	-----	-----
Chlorophyll *a* (ug/l)	1	4	-----	n.d.	n.d.	1	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	340[(2)] 150[(3)] 18[(4)]	0 0 0	0% 0% 0%
Beryllium, Dissolved (ug/l)	4	1	-----	n.d.	n.d.	n.d.	4[(4)]	0	0%
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	4.1[(2)] 0.4[(3)] 5[(4)]	0 b.d. 0	0% ----- 0%
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	100[(4)]	0	0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	26.6[(2)] 16.6[(3)] 1,300[(4)]	0 b.d. 0	0% ----- 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	140.5[(2)] 5.5[(3)] 15[(4)]	0 0 0	0% 0% 0%
Thallium, Dissolved, (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1.7[(4)]	b.d.	-----
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	863[(2)] 96[(3)] 100[(4)]	0 0 0	0% 0% 0%
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	12.0[(2)] 100[(4)]	0 0	0% 0%
Zinc, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	216[(1,2)] 2,000[(4)]	0 0	0% 0%
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	6[(4)]	b.d.	-----
Selenium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)] 50[(4)]	0 b.d. 0	0% ----- 0%
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	1.7[(2)] 0.91[(3)] 0.05[(4)]	0 0 b.d	0% 0% -----
Atrazine, Total (ug/l)	0.05	6	-----	n.d.	n.d.	0.6	≤3	0	0%
Metolachlor (ug/l)	0.05	6	-----	n.d.	n.d.	0.15	≤100	0	0%
Alachlor (ug/l)	0.05	6	------	n.d.	n.d.	n.d.	≤2	0	0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	****	0	0%

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[(4)]Human health criterion for surface waters.
Note: Montana's WQS criteria for metals are based on total recoverable, analyzed metal concentrations were dissolved.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Appendix A.2. Summary of Water Quality Conditions Monitored in the Fort Peck Dam Tailwaters during June-September, 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	0.1	3	12.3	10.8	10.3	15.8	≤ 19.4	0	0%
Dissolved Oxygen (mg/l)	0.1	3	8.7	9.3	6.5	10.2	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	3	84.0	82.4	70.4	99.3	-----	-----	-----
Specific Conductance (umho/cm)	1	2	550	550	534	566	-----	-----	-----
pH (S.U.)	0.1	3	-----	8.3	8.1	8.4	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	3	3.3	3.4	1.4	5.0	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	1	388	388	388	388	-----	-----	-----
Alkalinity, Total (mg/l)	7	5	158	159	150	168	-----	-----	-----
Ammonia, Total (mg/l)	0.01	4	-----	0.03	n.d.	0.09	1.5[1]	0	0%
Kjeldahl N, Total (mg/l)	0.1	5	-----	0.14	n.d.	0.59	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	5	n.d.	n.d.	n.d.	n.d.	-----	-----	-----
Hardness, Total (mg/l)	0.4	3	207	206	203	212	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	5	-----	0.02	n.d.	0.04	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	5	n.d.	n.d.	n.d.	n.d.	-----	-----	-----
Suspended Solids, Total (mg/l)	4	5	n.d.	n.d.	n.d.	n.d.	-----	-----	-----
Chemical Oxygen Demand ((mg/l)	2	1	4	4	4	4	-----	-----	-----
Total Organic Carbon (mg/l)	0.05	3	2.5	2.6	2.3	2.7	-----	-----	-----
Chlorophyll *a* (ug/l)	1	1	1	1	1	1	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	340[2] 150[3] 18[4]	0 0 0	0% 0% 0%
Beryllium, Dissolved (ug/l)	4	1	-----	n.d.	n.d.	n.d.	4[4]	0	0%
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	4.1[2] 0.4[3] 5[4]	0 b.d. 0	0% ----- 0%
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	100[4]	0	0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	26.6[2] 16.6[3] 1,300[4]	0 b.d. 0	0% ----- 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	140.5[2] 5.5[3] 15[4]	0 0 0	0% 0% 0%
Thallium, Dissolved, (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1.7[4]	b.d.	-----
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	863[2] 96[3] 100[4]	0 0 0	0% 0% 0%
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	12.0[2] 100[4]	0 0	0% 0%
Zinc, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	216[1,2] 2,000[4]	0 0	0% 0%
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	6[4]	b.d.	-----
Selenium, Dissolved (ug/l) Selenium, Total (ug/l)	10 10	1 1	----- -----	n.d. n.d.	n.d. n.d.	n.d. n.d.	20[2] 5[3] 50[4]	0 b.d. 0	0% ----- 0%
Mercury, Dissolved (ug/l) Mercury, Total (ug/l)	0.2 0.2	1 1	----- -----	n.d. n.d.	n.d. n.d.	n.d. n.d.	1.7[2] 0.91[3] 0.05[4]	0 0 b.d	0% 0% -----
Atrazine, Total (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	≤3	0	0%
Metolachlor (ug/l)	0.05	5	-----	n.d.	n.d.	0.11	≤100	0	0%
Alachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	≤2	0	0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	****	0	0%

n.d. = Not detected.
b.d. = WQS criterion below detection limit.

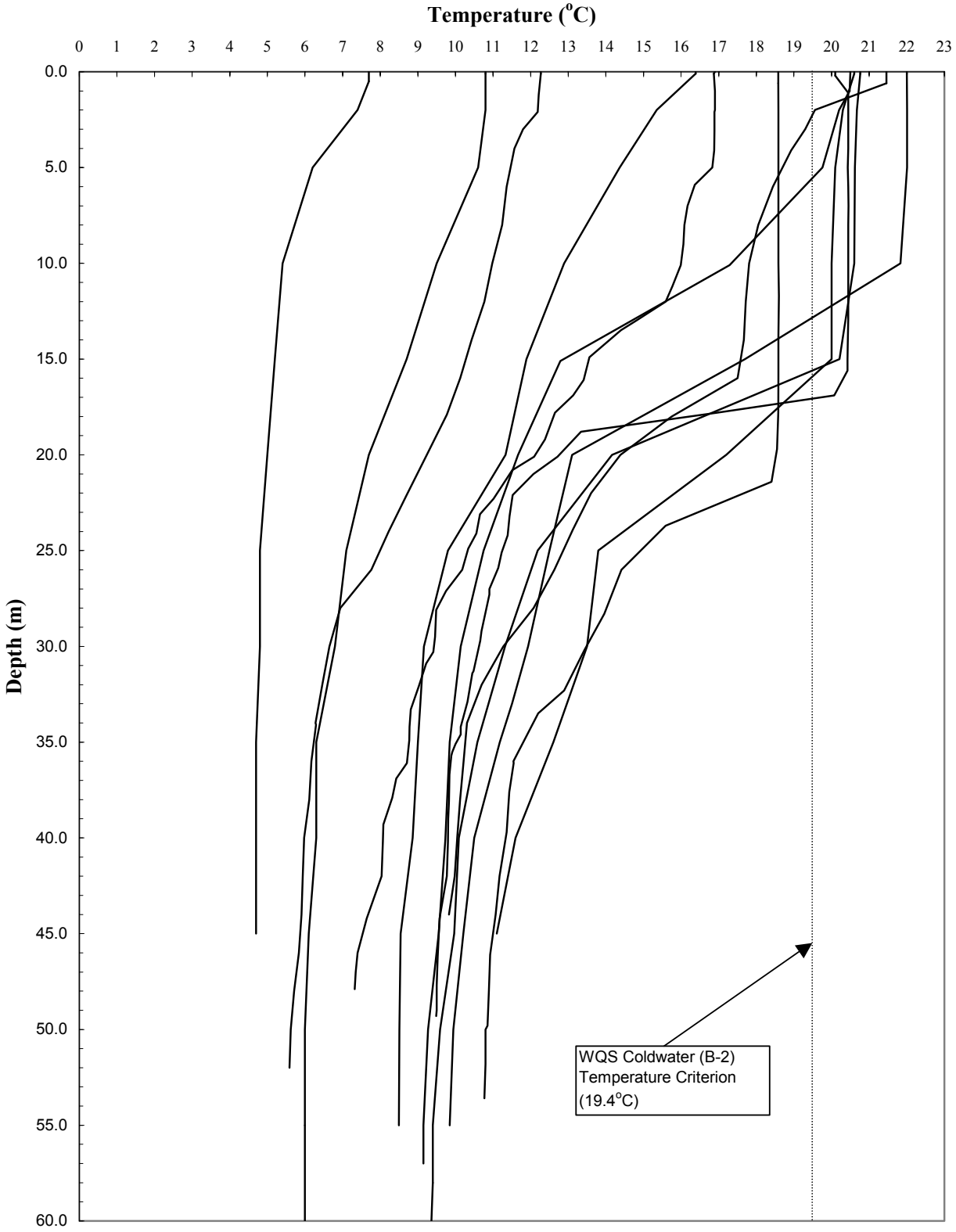
* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [1]Total ammonia criterion pH and temperature dependent.
[2] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[3] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[4]Human health criterion for surface waters.
Note: Montana's WQS criteria for metals are based on total recoverable, analyzed metal concentrations were dissolved.

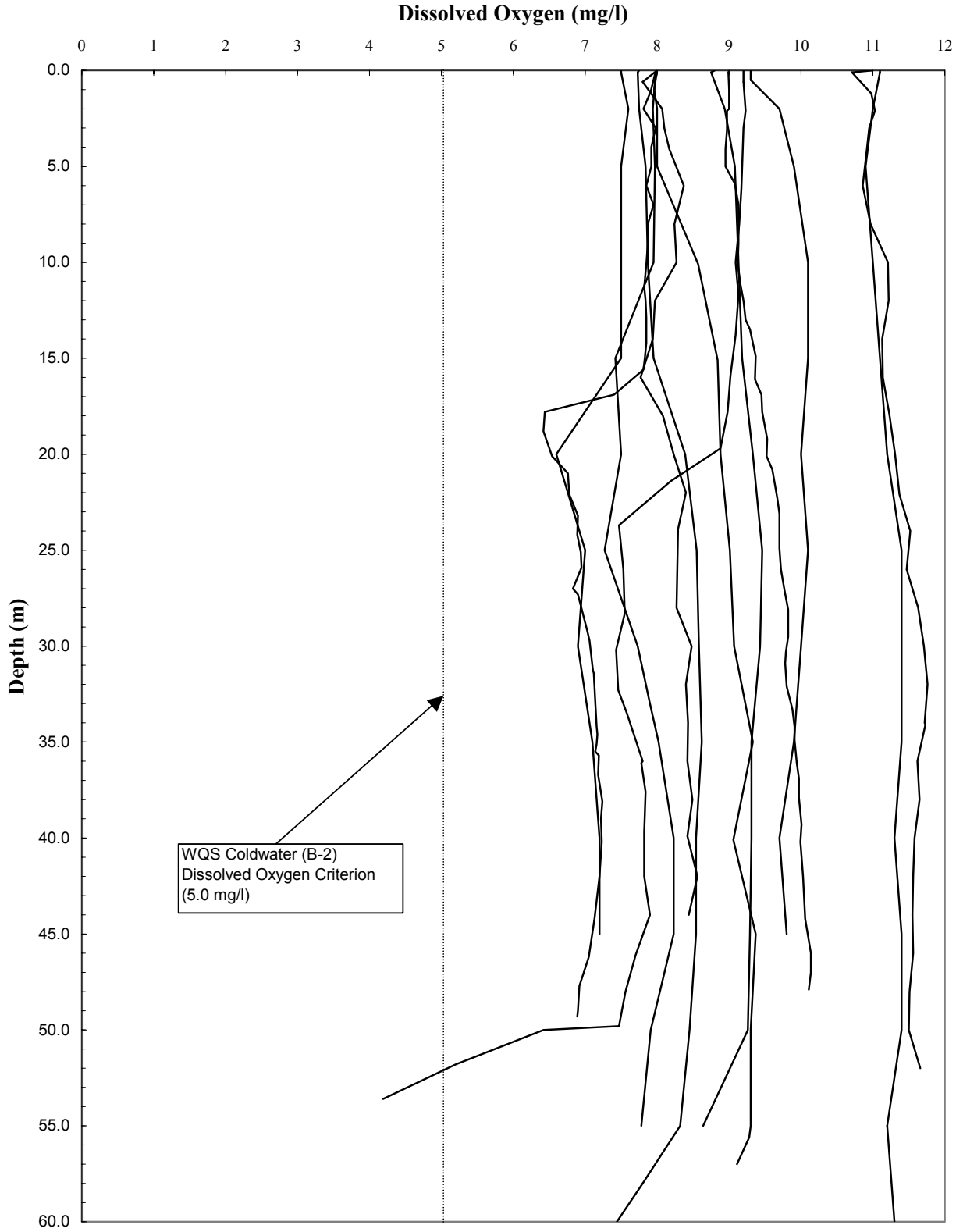
*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Appendix A.3. Temperature Depth Profiles for Fort Peck Lake Generated from Data Collected at the Long-Term In-Lake Fixed Monitoring Station during the 5-Year Period 1999-2003.



Appendix A.4. Dissolved Oxygen Depth Profiles for Fort Peck Lake Generated from Data Collected at the Long-term Fixed In-lake Monitoring Station during the 5-Year Period 1999-2003.



Appendix A.5. Summary of Water Quality Conditions Monitored at the In-Lake Intensive Survey Sites (IP1 – IP8) on Lake Sakakawea during June-September, 2003.

Parameter**	Detection Limit	In-Lake Site IP1					In-Lake Site IP2					In-Lake Site IP3				
		No. of Obs.	Mean*	Median	Min.	Max.	No. of Obs.	Mean*	Median	Min.	Max.	No. of Obs.	Mean*	Median	Min.	Max.
Water Temperature (°C)	0.1	351	14.5	15.5	6.6	22.3	331	15.1	15.6	7	22.1	303	15.4	16.6	7.0	22.1
Dissolved Oxygen (mg/l)	0.1	351	7.8	8.1	4.7	9.6	331	7.7	7.9	4.4	9.5	303	7.6	7.9	4.3	9.7
Dissolved Oxygen (% Sat.)	0.1	350	80.3	84.4	46.0	99.1	330	79.6	85.0	42.7	102.9	300	80.0	85.4	42.3	108.8
Specific Conductance (umho/cm)	1	350	618	617	598	636	330	614	615	592	633	300	607	609	582	628
pH (S.U.)	0.1	350	-----	8.0	7.1	8.4	330	-----	8.0	7.1	8.4	300	-----	8.0	6.9	8.3
Turbidity (NTUs)	0.1	350	2.9	2.5	0.1	13.8	329	3.2	2.4	n.d.	14.5	299	3.6	2.8	n.d.	17.6
Oxidation-Reduction Potential (mV)	1	350	391	376	332	527	330	387	375	324	514	300	390	373	319	520
Secchi Depth (in.)	1	8	139	123	100	228	8	132	120	96	180	8	119	117	90	150
Alkalinity, Total (mg/l)	7	10	169	167	162	181	9	161	161	157	165	10	165	163	155	181
Ammonia, Total (mg/l)	0.01	10	0.58	0.53	0.35	1.20	6	0.54	0.40	0.37	1.30	10	0.58	0.53	0.38	1.20
Kjeldahl N, Total (mg/l)	0.1	10	0.9	0.8	0.6	1.6	6	0.8	0.6	0.5	1.5	10	0.8	0.8	0.6	1.4
Nitrate-Nitrite N, Total (mg/l)	0.02	10	0.09	0.08	0.03	0.18	9	0.12	0.10	0.07	0.19	10	0.12	0.10	0.04	0.22
Phosphorus, Total (mg/l)	0.01	9	-----	0.02	n.d.	0.08	8	0.04	0.03	0.02	0.08	9	0.02	0.02	0.01	0.05
Orthophosphorus, Dissolved (mg/l)	0.01	10	-----	n.d.	n.d.	n.d.	9	-----	n.d.	n.d.	n.d.	10	-----	n.d.	n.d.	n.d.
Sulfate (mg/l)	0.01	10	167	162	153	188	9	164	159	145	188	10	163	157	153	183
Suspended Solids, Total (mg/l)	4	10	-----	n.d.	n.d.	5	9	-----	n.d.	n.d.	n.d.	10	-----	5.5	n.d.	13
Dissolved Solids, Total (mg/l)	5	10	436	379	363	572	9	370	381	276	444	10	423	373	352	551
Total Organic Carbon (mg/l)	0.05	10	3.0	3.0	2.8	3.4	9	3.1	3.1	2.7	3.5	10	3.1	3.1	2.1	3.6
Chlorophyll *a* (ug/l)	1	4	2	2	1	2	4	2	2	1	2	4	2	2	1	3
Silica, Total (mg/l)	0.02	9	3.1	3.0	2.7	3.3	8	3.1	3.2	2.8	3.8	9	3.2	3.2	2.8	3.6
Iron, Total (ug/l)	100	3	-----	100	n.d.	109	3	-----	n.d.	n.d.	219	3	-----	433	n.d	440
Manganese, Total (ug/l)	10	3	-----	n.d.	n.d.	n.d.	3	-----	n.d.	n.d.	23	3	-----	27	n.d.	46
Pesticide Scan (ug/l)***	0.05	1	n.d.	n.d.	n.d.	n.d.										

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Water temperature, dissolved oxygen (mg/l), dissolved oxygen (% saturation), specific conductance, pH, turbidity, and oxidation-reduction potential results based on 1-meter incremental depth profile measurements. Pesticide results are based on analysis of a near-surface grab sample. Iron and manganese results are based on analyses of only near-bottom "grab" samples. All other parameters are based on varying combinations of "grab" samples collected at mid-Secchi, mid-metalimnion, and near-bottom depths.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan. A near-surface water sample for pesticide analysis was collected in June at only Site IP1.

Appendix A.5. (Continued).

Parameter**	Detection Limit	In-Lake Site IP4					In-Lake Site IP5					In-Lake Site IP6				
		No. of Obs.	Mean*	Median	Min.	Max.	No. of Obs.	Mean*	Median	Min.	Max.	No. of Obs.	Mean*	Median	Min.	Max.
Water Temperature (°C)	0.1	239	16.4	16.6	7.3	23.0	205	16.5	17.4	8.1	22.4	171	17.7	19.3	8.3	22.6
Dissolved Oxygen (mg/l)	0.1	239	7.5	7.9	3.2	9.1	205	7.1	7.6	2.7	9.0	171	6.9	7.3	1.9	8.5
Dissolved Oxygen (% Sat.)	0.1	239	80.5	84.8	32.0	101.1	205	77.0	81.0	28.3	106.4	168	77.2	83.2	20.6	100.1
Specific Conductance (umho/cm)	1	239	592	592	546	640	204	573	576	497	652	168	522	507	422	631
pH (S.U.)	0.1	239	-----	8.1	7.1	8.3	205	-----	8.0	7.1	8.5	168	-----	8.0	7.0	8.3
Turbidity (NTUs)	0.1	239	4.2	3.2	n.d.	21.6	204	10.2	5.0	1.9	55.6	168	14.7	9.4	4.3	91
Oxidation-Reduction Potential (mV)	1	239	384	378	295	527	204	393	386	324	528	168	382	379	325	487
Secchi Depth (in.)	1	8	105	114	63	122	7	83	86	36	108	7	45	48	19	60
Alkalinity, Total (mg/l)	7	8	157	154	145	176	9	151	148	141	172	4	122	123	108	135
Ammonia, Total (mg/l)	0.01	5	0.59	0.39	0.39	1.30	8	0.64	0.59	0.40	1.30	3	0.68	0.38	0.36	1.30
Kjeldahl N, Total (mg/l)	0.1	5	0.8	0.7	0.5	1.4	9	0.8	0.8	0.3	1.5	3	1.0	0.7	0.7	1.5
Nitrate-Nitrite N, Total (mg/l)	0.02	8	0.15	0.13	0.09	0.24	9	0.13	0.12	0.05	0.22	4	0.14	0.14	0.06	0.21
Phosphorus, Total (mg/l)	0.01	7	0.03	0.02	0.02	0.04	8	0.04	0.04	0.02	0.05	4	0.07	0.06	0.03	0.13
Orthophosphorus, Dissolved (mg/l)	0.01	8	-----	n.d.	n.d.	n.d.	9	-----	n.d.	n.d.	n.d.	4	-----	n.d.	n.d.	n.d.
Sulfate (mg/l)	0.01	8	157	154	132	179	9	141	147	119	156	4	114	116	88	138
Suspended Solids, Total (mg/l)	4	8	-----	n.d.	n.d.	5	9	-----	6.5	n.d.	19	4	8.4	6	4.5	17
Dissolved Solids, Total (mg/l)	5	8	360	362	282	420	9	365	340	326	451	4	280	287	236	310
Total Organic Carbon (mg/l)	0.05	8	3.1	3.0	2.9	3.5	9	3.3	3.2	2.9	3.7	4	2.9	2.8	2.7	3.2
Chlorophyll *a* (ug/l)	1	4	3	3	2	3	4	5	5	2	8	3	4	5	3	5
Silica, Total (mg/l)	0.02	7	3.4	3.3	3.1	3.7	8	3.6	3.5	3.1	4.3	3	4.1	4.1	3.6	4.7
Iron, Total (ug/l)	100	2	-----	-----	n.d.	190	3	-----	317	n.d.	910	1	767	767	767	767
Manganese, Total (ug/l)	10	2	-----	-----	n.d.	28	3	42.6	27.8	23	77	1	61	61	61	61

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Water temperature, dissolved oxygen (mg/l), dissolved oxygen (% saturation), specific conductance, pH, turbidity, and oxidation-reduction potential results based on 1-meter incremental depth profile measurements. Iron and manganese results are based on analyses of only near-bottom "grab" samples. All other parameters are based on varying combinations of "grab" samples collected at mid-Secchi, mid-metalimnion, and near-bottom depths.

Appendix A.5. (Continued).

Parameter**	Detection Limit	In-Lake Site IP7					In-Lake Site IP8				
		No. of Obs.	Mean*	Median	Min.	Max.	No. of Obs.	Mean*	Median	Min.	Max.
Water Temperature (°C)	0.1	97	20.2	20.3	12.7	23.4	54	21.2	22.2	16.5	24.1
Dissolved Oxygen (mg/l)	0.1	97	7.2	7.3	4.8	8.3	54	7.3	7.4	5.2	8.2
Dissolved Oxygen (% Sat.)	0.1	96	83.8	86.2	51.1	104.9	54	86.3	88.2	60.3	104.7
Specific Conductance (umho/cm)	1	95	462	465	335	618	54	436	460	332	533
pH (S.U.)	0.1	96	-----	8.1	7.5	8.2	54	-----	8.1	7.8	8.2
Turbidity (NTUs)	0.1	96	35.5	28.0	10.5	84.1	53	54.3	44.4	23.6	154.2
Oxidation-Reduction Potential (mV)	1	96	381	380	302	495	54	367	371	161	407
Secchi Depth (in.)	1	7	21	24	10	36	5	13.4	14	8	18
Alkalinity, Total (mg/l)	7	8	117	117	83	146	5	109	114	52	148
Ammonia, Total (mg/l)	0.01	8	0.62	0.57	0.41	1.2	2	0.8	0.8	0.4	1.2
Kjeldahl N, Total (mg/l)	0.1	8	0.9	0.8	0.7	1.6	3	0.7	0.7	0.1	1.4
Nitrate-Nitrite N, Total (mg/l)	0.02	8	n.d.	0.08	n.d.	0.18	5	0.05	0.04	0.02	0.11
Phosphorus, Total (mg/l)	0.01	7	0.03	0.03	0.02	0.05	5	0.06	0.06	0.04	0.09
Orthophosphorus, Dissolved (mg/l)	0.01	8	-----	n.d.	n.d.	n.d.	5	-----	n.d.	n.d.	n.d.
Sulfate (mg/l)	0.01	8	100	95	73	151	5	105	101	72	146
Suspended Solids, Total (mg/l)	4	8	10	12	n.d.	14	5	16.8	13	11	29
Dissolved Solids, Total (mg/l)	5	8	290	271	240	462	5	281	280	243	336
Total Organic Carbon (mg/l)	0.05	8	2.6	2.6	2.5	2.9	5	2.6	2.6	2.3	3.2
Chlorophyll *a* (ug/l)	1	4	3	3	1	5	3	4	4	3	5
Silica, Total (mg/l)	0.02	7	4.2	4.2	4.1	4.4	4	4.3	4.2	4.1	4.5
Iron, Total (ug/l)	100	2	705	705	700	710	1	650	650	650	650
Manganese, Total (ug/l)	10	2	21	21	16	26	1	17	17	17	17

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Water temperature, dissolved oxygen (mg/l), dissolved oxygen (% saturation), specific conductance, pH, turbidity, and oxidation-reduction potential results based on 1-meter incremental depth profile measurements. Iron and manganese results are based on analyses of only near-bottom "grab" samples. All other parameters are based on varying combinations of "grab" samples collected at mid-Secchi, mid-metalimnion, and near-bottom depths.

Appendix A.6. Summary of Water Quality Conditions Monitored at the Inflow and Outflow Intensive Survey Sites (BC1, BC2, and BC4) at Lake Sakakawea during June-September, 2003.

Parameter**	Detection Limit	Inflow Site BC1					Inflow Site BC2					Outflow Site BC4				
		No. of Obs.	Mean*	Median	Min.	Max.	No. of Obs.	Mean*	Median	Min.	Max.	No. of Obs.	Mean*	Median	Min.	Max.
Water Temperature (°C)	0.1	6	21.0	22.7	11.5	24.5	4	23.0	22.3	21.0	26.3	2,402	12.5	12.5	7.4	19.0
Dissolved Oxygen (mg/l)	0.1	6	7.7	7.6	7.0	9.1	4	6.8	6.8	6.4	7.1	2,402	7.3	7.1	4.3	10.2
Dissolved Oxygen (% Sat.)	0.1	6	89.4	89.6	86.6	92	4	82.2	83.1	77.0	85.6	2,402	75.7	72.7	42.6	105.3
Specific Conductance (umho/cm)	1	6	566	590	460	631	4	1,521	1,516	1,250	1,803	2,402	623	612	605	666
pH (S.U.)	0.1	6	-----	8.2	8.0	8.2	4	-----	8.2	8.1	8.3	2,402	-----	7.9	7.3	8.8
Turbidity (NTUs)	0.1	6	-----	78.1	37.6	>1,000	4	>1,000	>1,000	>1,000	>1,000	4	15.6	10.3	6.4	35.2
Oxidation-Reduction Potential (mV)	1	6	396	386	324	482	4	419	414	382	464	2,402	508	508	360	595
Alkalinity, Total (mg/l)	7	6	152	164	91	177	5	240	228	200	298	7	167	165	158	177
Ammonia, Total (mg/l)	0.01	5	0.48	0.44	0.37	0.72	3	0.36	0.43	0.21	0.45	6	0.46	0.43	0.37	0.66
Kjeldahl N, Total (mg/l)	0.1	6	0.63	0.65	0.38	0.9	5	5.6	5.7	2.9	8.0	6	0.7	0.7	0.6	1.0
Nitrate-Nitrite N, Total (mg/l)	0.02	8	-----	n.d.	n.d.	0.11	5	0.83	0.94	0.54	1.10	7	0.10	0.09	0.03	0.18
Phosphorus, Total (mg/l)	0.01	8	0.21	0.10	0.07	0.65	5	4.50	4.80	3.40	5.60	8	0.04	0.03	n.d.	0.11
Orthophosphorus, Dissolved (mg/l)	0.01	8	-----	n.d.	n.d.	0.03	3	-----	n.d.	n.d.	0.01	6	-----	n.d.	n.d.	n.d.
Sulfate (mg/l)	0.01	7	128	135	67	182	5	592	603	440	748	7	164	159	146	188
Suspended Solids, Total (mg/l)	4	8	202	91	47	541	5	7,312	7,610	3,470	10,700	7	-----	n.d.	n.d.	10
Dissolved Solids, Total (mg/l)	5	8	375	387	196	564	5	1,619	1,304	990	2,435	7	430	404	370	530
Total Organic Carbon (mg/l)	0.05	8	2.7	2.6	2.4	3.7	5	11.1	11.0	9.5	13.0	7	2.9	2.9	2.8	3.1
Silica, Total (mg/l)	0.02	6	5.7	4.6	3.8	8.9	4	27.2	21.1	4.4	62.3	7	4.1	3.2	3.0	6.6
Iron, Total (ug/l)	100	1	2,410	2,410	2,410	2,410	0	-----	-----	-----	-----	6	-----	130	n.d.	300
Manganese, Total (ug/l)	10	1	60	60	60	60	0	-----	-----	-----	-----	6	-----	n.d.	n.d.	14

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Water temperature, dissolved oxygen (mg/l and % saturation) specific conductance, pH, and ORP statistical summary at Site BC4 based on hourly measurements recorded by a data logger installed in the Garrison Dam powerhouse.

Appendix A.7. Summary of Water Quality Standards Attainment Based on Data Collected during 2003 at Lake Sakakawea Intensive Survey Monitoring Sites.

Parameter	State WQS Criteria*	In-Lake Site IP1			In-Lake Site IP2			In-Lake Site IP3			In-Lake Site IP-4		
		No. of Obs.	No. of WQS Exceedences	Percent WQS Exceedence	No. of Obs.	No. of WQS Exceedences	Percent WQS Exceedence	No. of Obs.	No. of WQS Exceedences	Percent WQS Exceedence	No. of Obs.	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	≤ 29.4[(1)]	351	0	0%	331	0	0%	303	0	0%	239	0	0%
	≤ 18.3[(1)]		96	27%		95	29%		96	32%		85	36%
	≤ 15.0[(1)]		185	53%		177	54%		171	56%		158	66%
Dissolved Oxygen (mg/l)	≥ 5.0	351	2	1%	331	16	5%	303	14	5%	239	21	9%
pH (S.U.)	≥7.0 & ≤9.0	350	0	0%	330	0	0%	300	7	2%	239	0	0%
Ammonia, Total (mg/l)	3.8[(2)]	10	0	0%	6	0	0%	10	0	0%	5	0	0%
	1.8[(3)]		0	0%		0	0%		0	0%		0	0%
Nitrate-Nitrite N, Total (mg/l)	1.0	10	0	0%	9	0	0%	10	0	0%	8	0	0%
Phosphorus, Total (mg/l)	0.1	9	0	0%	8	0	0%	9	0	0%	7	0	0%
Sulfate (mg/l)	250	10	0	0%	9	0	0%	10	0	0%	8	0	0%

Parameter	State WQS Criteria*	In-Lake Site IP5			In-Lake Site IP6			In-Lake Site IP7			In-Lake Site IP18		
		No. of Obs.	No. of WQS Exceedences	Percent WQS Exceedence	No. of Obs.	No. of WQS Exceedences	Percent WQS Exceedence	No. of Obs.	No. of WQS Exceedences	Percent WQS Exceedence	No. of Obs.	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	≤ 29.4[(1)]	205	0	0%	171	0	0%	97	0	0%	54	0	0%
	≤ 18.3[(1)]		95	46%		101	59%		81	84%		48	89%
	≤ 15.0[(1)]		131	64%		123	72%		91	94%		54	100%
Dissolved Oxygen (mg/l)	≥ 5.0	205	16	8%	171	17	10%	97	1	1%	54	0	0%
pH (S.U.)	≥7.0 & ≤9.0	205	0	0%	168	0	0%	96	0	0%	54	0	0%
Ammonia, Total (mg/l)	3.8[(2)]	8	0	0%	3	0	0%	8	0	0%	2	0	0%
	1.8[(3)]		0	0%		0	0%		0	0%		0	0%
Nitrate-Nitrite N, Total (mg/l)	1.0	9	0	0%	4	0	0%	8	0	0%	5	0	0%
Phosphorus, Total (mg/l)	0.1	8	0	0%	4	1	25%	7	0	0%	5	0	0%
Sulfate (mg/l)	250	9	0	0%	4	0	0%	8	0	0%	5	0	0%

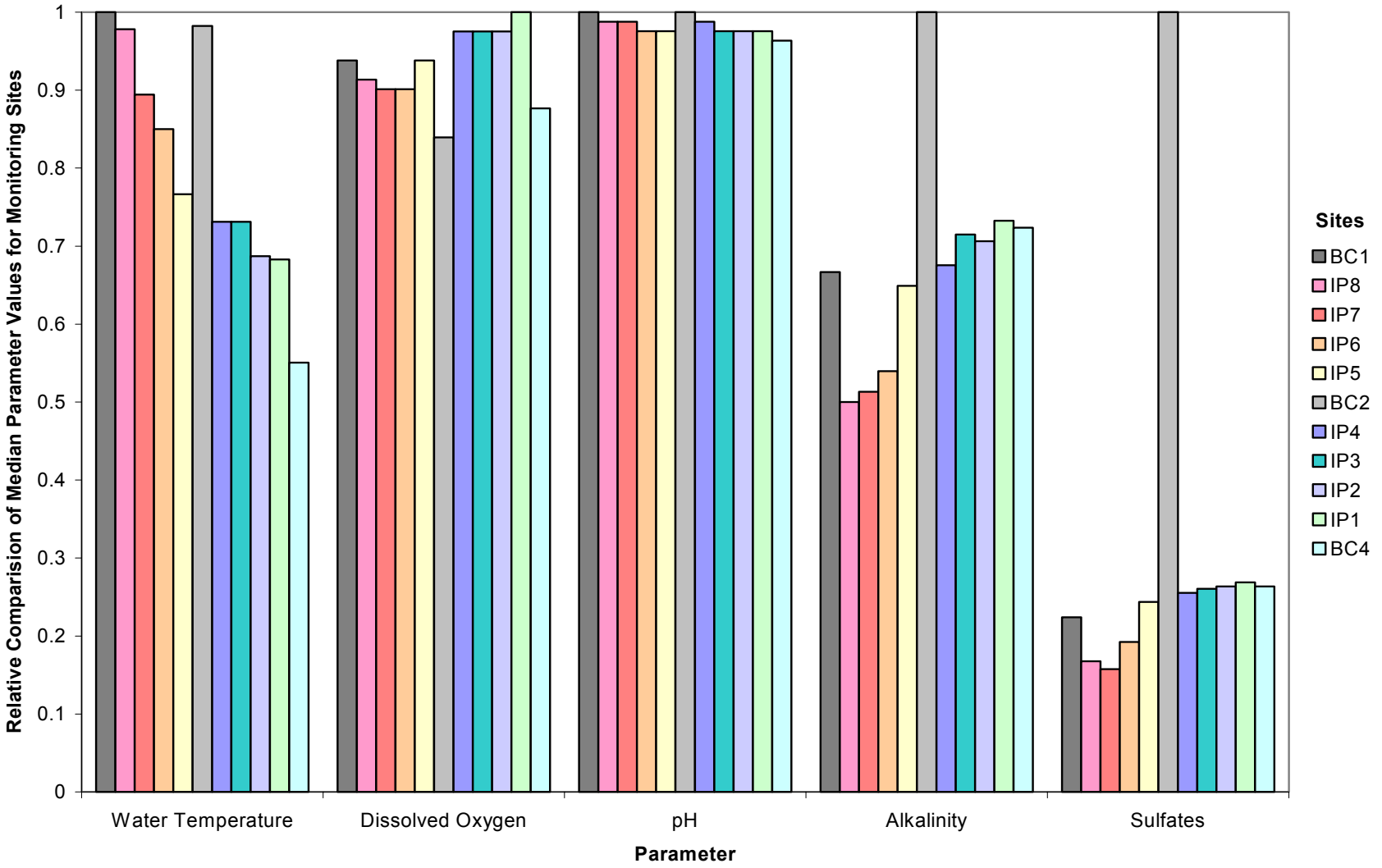
Parameter	State WQS Criteria*	Inflow Site BC1			Inflow Site BC2			Outflow Site BC4		
		No. of Obs.	No. of WQS Exceedences	Percent WQS Exceedence	No. of Obs.	No. of WQS Exceedences	Percent WQS Exceedence	No. of Obs.	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	≤ 29.4[(1)]	6	0	0%	4	0	0%	2,402	0	0%
	≤ 18.3[(1)]		5	83%		4	100%		21	1%
	≤ 15.0[(1)]		5	83%		4	100%		357	15%
Dissolved Oxygen (mg/l)	≥ 5.0	6	0	0%	4	0	0%	2,402	202	8%
pH (S.U.)	≥7.0 & ≤9.0	6	0	0%	4	0	0%	2,402	0	0%
Ammonia, Total (mg/l)	3.8[(2)]	5	0	0%	3	0	0%	6	0	0%
	1.8[(3)]		0	0%		0	0%		0	0%
Nitrate-Nitrite N, Total (mg/l)	1.0	8	0	0%	5	1	20%	7	0	0%
Phosphorus, Total (mg/l)	0.1	8	4	50%	5	5	100%	8	0	0%
Sulfate (mg/l)	250	7	0	0%	5	5	100%	7	0	0%

* [(1)]Numeric temperature criterion given in North Dakota water quality standards is 29.4. No specific numeric temperature criteria identified for coldwater aquatic life. The 18.3 and 15.0 °C levels are given for comparison purposes.

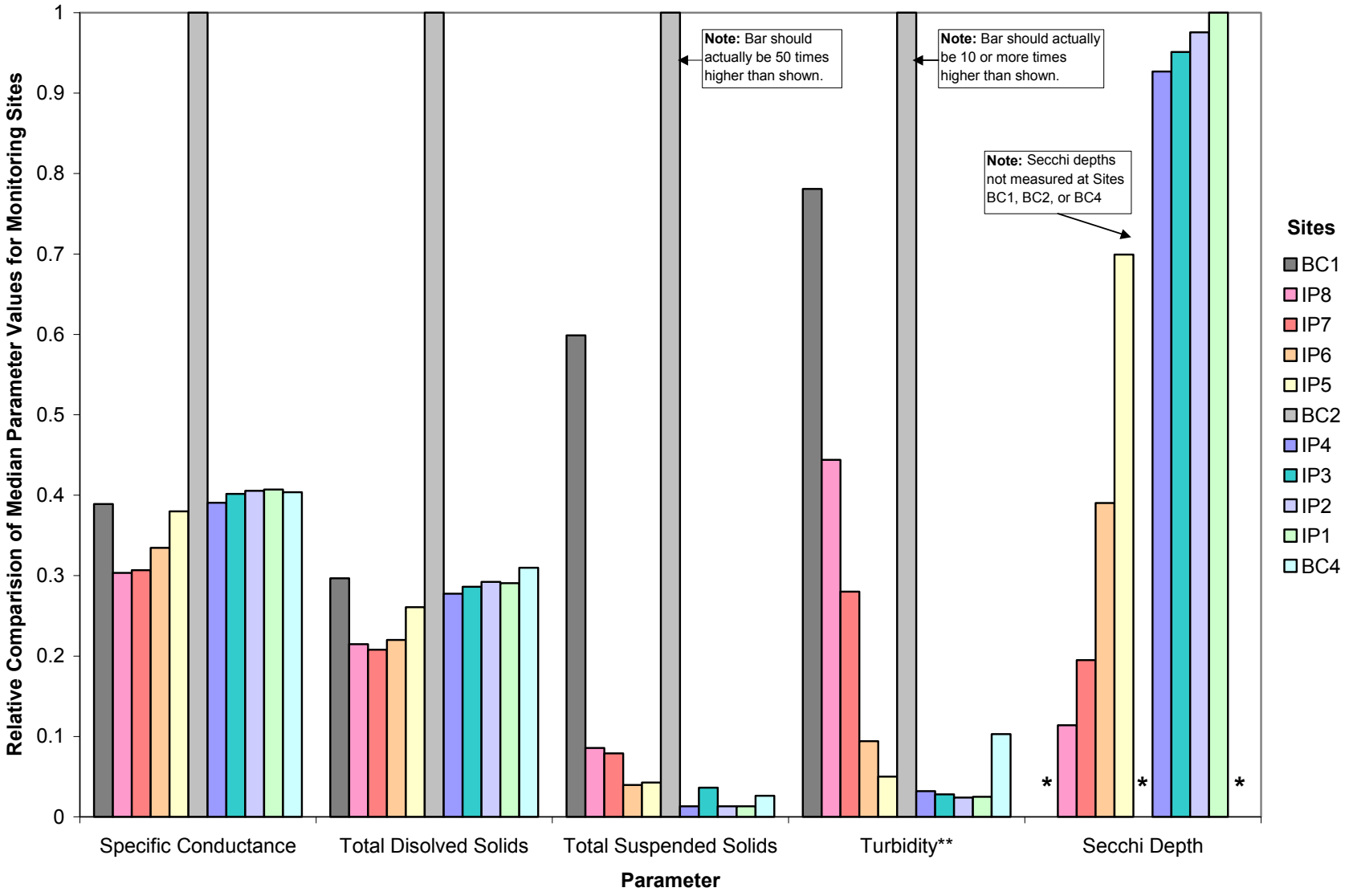
[(2)]Total ammonia acute criterion – 1-hour average and pH and temperature dependent.

[(3)]Total ammonia chronic criterion – 30-day average and pH and temperature dependent.

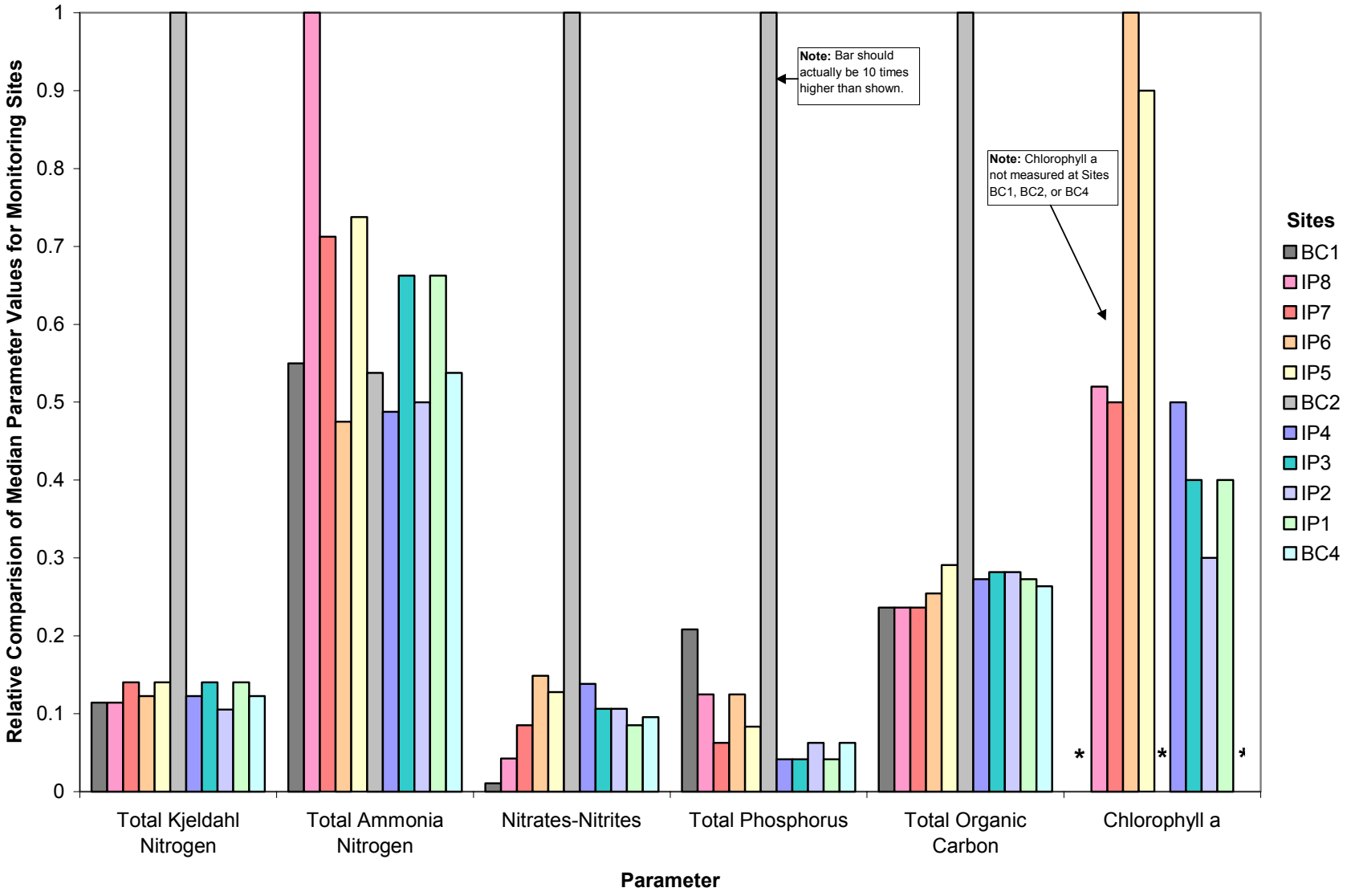
Appendix 8. Median Values of Selected Parameters Determined from Data Collected at the 11 Lake Sakakawea Intensive Survey Monitoring Sites. (Note: The monitoring sites are ordered relative to their respective location from upstream to downstream.)



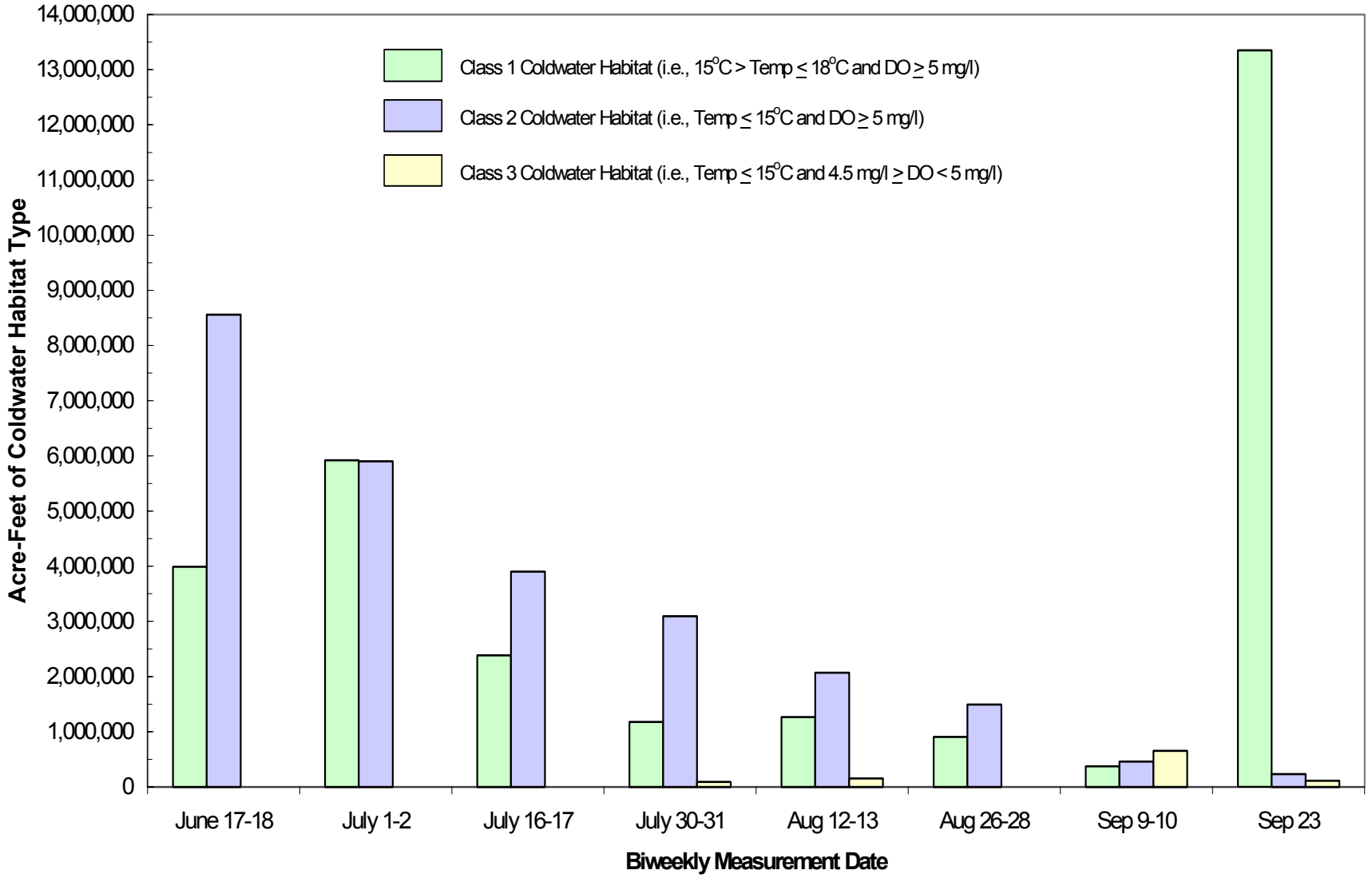
Appendix 8. (Continued).



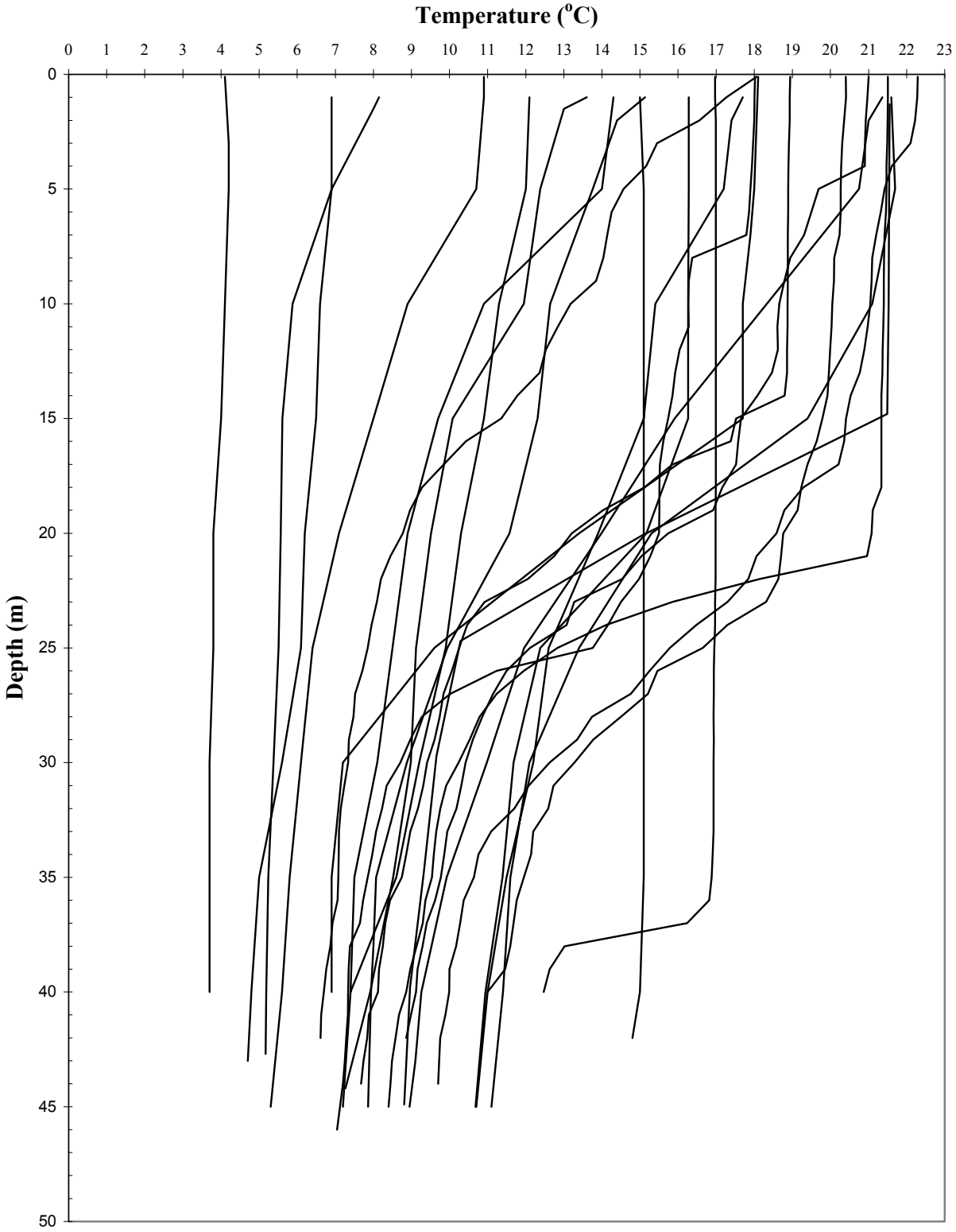
Appendix 8. (Continued).



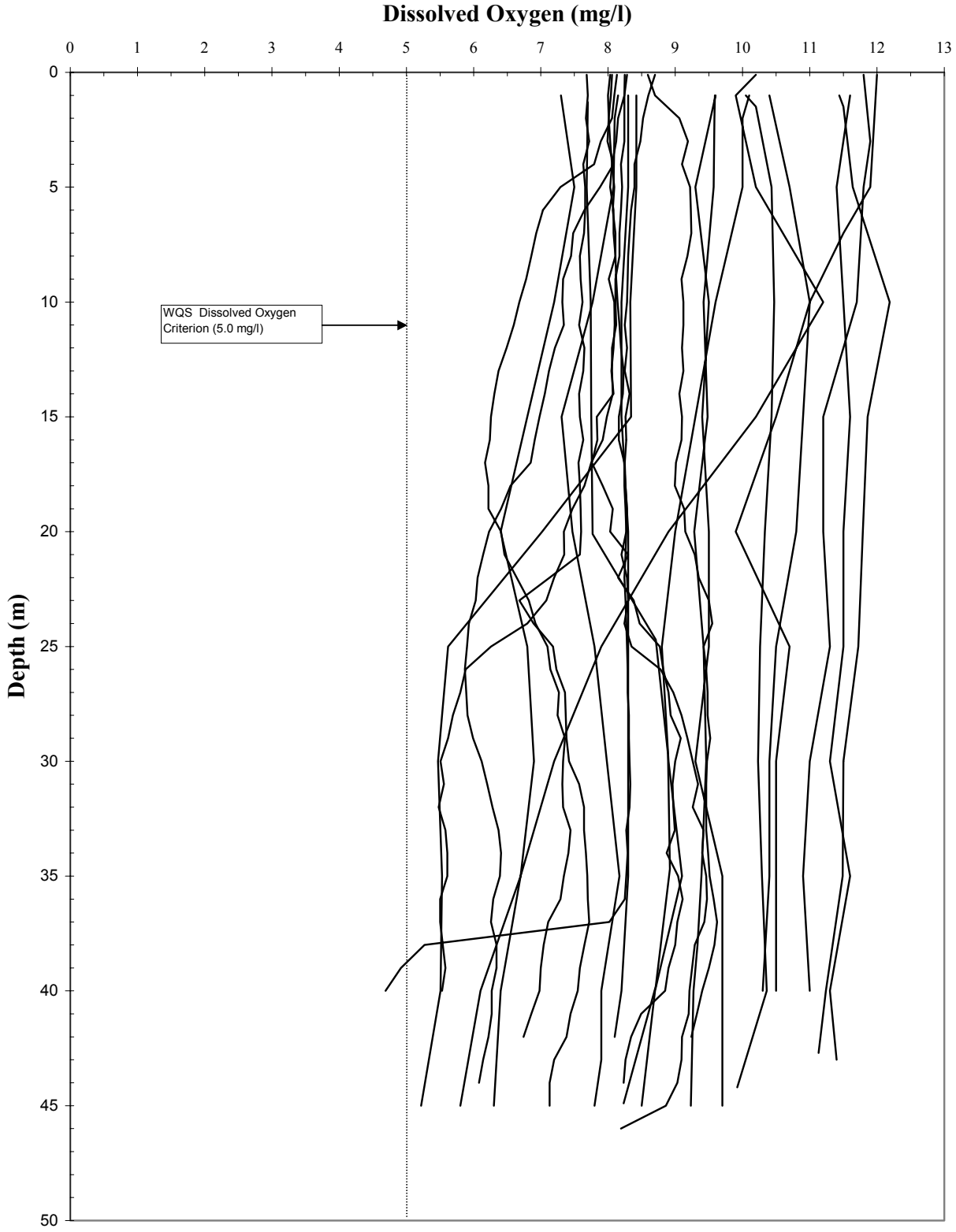
Appendix 9. Estimated Occurrence of Coldwater Habitat in Lake Sakakawea during 2003 Based on Biweekly Temperature and Dissolved Oxygen Depth Profile Measurements Taken at the Eight Intensive Survey Monitoring Sites.



Appendix A.10. Temperature Depth Profiles for Lake Sakakawea Generated from Data Collected at the Long-Term In-Lake Fixed Monitoring Station during the 5-Year Period 1999-2003.



Appendix A.11. Dissolved Oxygen Depth Profiles for Lake Sakakawea Generated from Data Collected at the Long-term Fixed In-lake Monitoring Station during the 5-Year Period 1999-2003.



Appendix A.12. Summary of Water Quality Conditions Monitored in Lake Oahe at the Deepwater, Near-dam Location during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	0.1	215	13.1	10.9	6.9	24.2	≤ 18.3	31	14.4%
Dissolved Oxygen (mg/l)	0.1	215	8.9	8.6	6.7	10.9	≥ 6.0 ≥ 7.0	0 5	0% 2.3%
Dissolved Oxygen (% Sat.)	0.1	215	87.9	90.1	66.7	107.2	-----	-----	-----
Specific Conductance (umho/cm)	1	215	713	711	687	732	-----	-----	-----
pH (S.U.)	0.1	215	-----	8.1	7.4	8.6	≥6.6 & ≤8.6	0	0%
Turbidity (NTUs)	0.1	173	3.2	2.3	0.1	10.2	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	174	353	358	292	388	-----	-----	-----
Secchi Depth (in.)	1	5	160	172	101	180	-----	-----	-----
Alkalinity, Total (mg/l)	7	10	171	175	153	181	-----	-----	-----
Ammonia, Total (mg/l)	0.01	10	-----	0.41	n.d.	0.47	≤ 0.8[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	-----	0.6	n.d.	0.73	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	0.07	≤ 10	0	0%
Hardness, Total (mg/l)	0.4	2	241.5	241.5	241	242	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	-----	0.02	n.d.	0.03	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	10	-----	n.d.	n.d.	n.d.	-----	-----	-----
Suspended Solids, Total (mg/l)	4	4	-----	n.d.	n.d.	n.d.	≤ 53	0	0%
Total Organic Carbon (mg/l)	0.05	10	3.1	3.1	3.0	3.4	-----	-----	-----
Chlorophyll *a* (ug/l)	1	5	1	1	1	2	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	360[(2)] 190[(3)] 18[(4)]	0 0 0	0% 0% 0%
Beryllium, Dissolved (ug/l)	4	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	9.6[(2)] 2.0[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,137[(2)] 367[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	39.1[(2)] 24.2[(3)] 1,300[(4)]	0 0 0	0% 0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	166.6[(2)] 6.5[(3)]	0 0	0% 0%
Thallium, Dissolved, (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1.7[(4)]	b.d.	-----
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	2,989[(2)] 332[(3)] 610[(4)]	0 0 0	0% 0% 0%
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	15.8[(2)]	0	0%
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	14[(4)]	b.d.	-----
Selenium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	2.1[(2)] 0.012[(3)] 0.14[(4)]	0 b.d. b.d	0% ----- -----
Atrazine, Total (ug/l)	0.05	5	-----	0.06	n.d.	0.07	-----	-----	-----
Metolachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Alachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[(4)] Domestic drinking water supply.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.13. Summary of Water Quality Conditions Monitored in the Oahe Dam Tailwaters during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	0.1	5	16.8	17.4	9.2	22.7	≤ 18.3	1	20.0%
Dissolved Oxygen (mg/l)	0.1	5	8.9	8.9	7.9	9.6	≥ 6.0 ≥ 7.0	0 0	0% 0%
Dissolved Oxygen (% Sat.)	0.1	5	95.1	94.3	87.6	104.6	-----	-----	-----
Specific Conductance (umho/cm)	1	5	709	709	689	731	-----	-----	-----
pH (S.U.)	0.1	5	-----	8.3	7.1	8.3	≥6.6 & ≤8.6	0	0%
Turbidity (NTUs)	0.1	4	5.3	4.6	0.5	11.5	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	4	342	347	304	370	-----	-----	-----
Alkalinity, Total (mg/l)	7	5	164	169	139	177	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	-----	0.41	n.d.	1.2	≤ 0.24[(1)]	2	40%
Kjeldahl N, Total (mg/l)	0.1	5	-----	0.6	n.d.	2.3	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	5	-----	n.d.	n.d.	n.d.	≤ 10	0	0%
Hardness, Total (mg/l)	0.4	1	263	263	263	263	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	5	-----	0.01	n.d.	0.08	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	10	-----	n.d.	n.d.	n.d.	-----	-----	-----
Suspended Solids, Total (mg/l)	4	4	-----	n.d.	n.d.	n.d.	≤ 53	0	0%
Total Organic Carbon (mg/l)	0.05	5	3.0	3.0	3.0	3.2	-----	-----	-----
Chlorophyll *a* (ug/l)	1	5	1	1	1	1	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	360[(2)] 190[(3)] 18[(4)]	0 0 0	0% 0% 0%
Beryllium, Dissolved (ug/l)	4	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	9.6[(2)] 2.0[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,137[(2)] 367[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	39.1[(2)] 24.2[(3)] 1,300[(4)]	0 0 0	0% 0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	166.6[(2)] 6.5[(3)]	0 0	0% 0%
Thallium, Dissolved, (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1.7[(4)]	b.d.	-----
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	2,989[(2)] 332[(3)] 610[(4)]	0 0 0	0% 0% 0%
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	15.8[(2)]	0	0%
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	14[(4)]	b.d.	-----
Selenium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	2.1[(2)] 0.012[(3)] 0.14[(4)]	0 b.d. b.d	0% ----- -----
Atrazine, Total (ug/l)	0.05	5	-----	n.d.	n.d.	0.07	-----	-----	-----
Metolachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Alachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

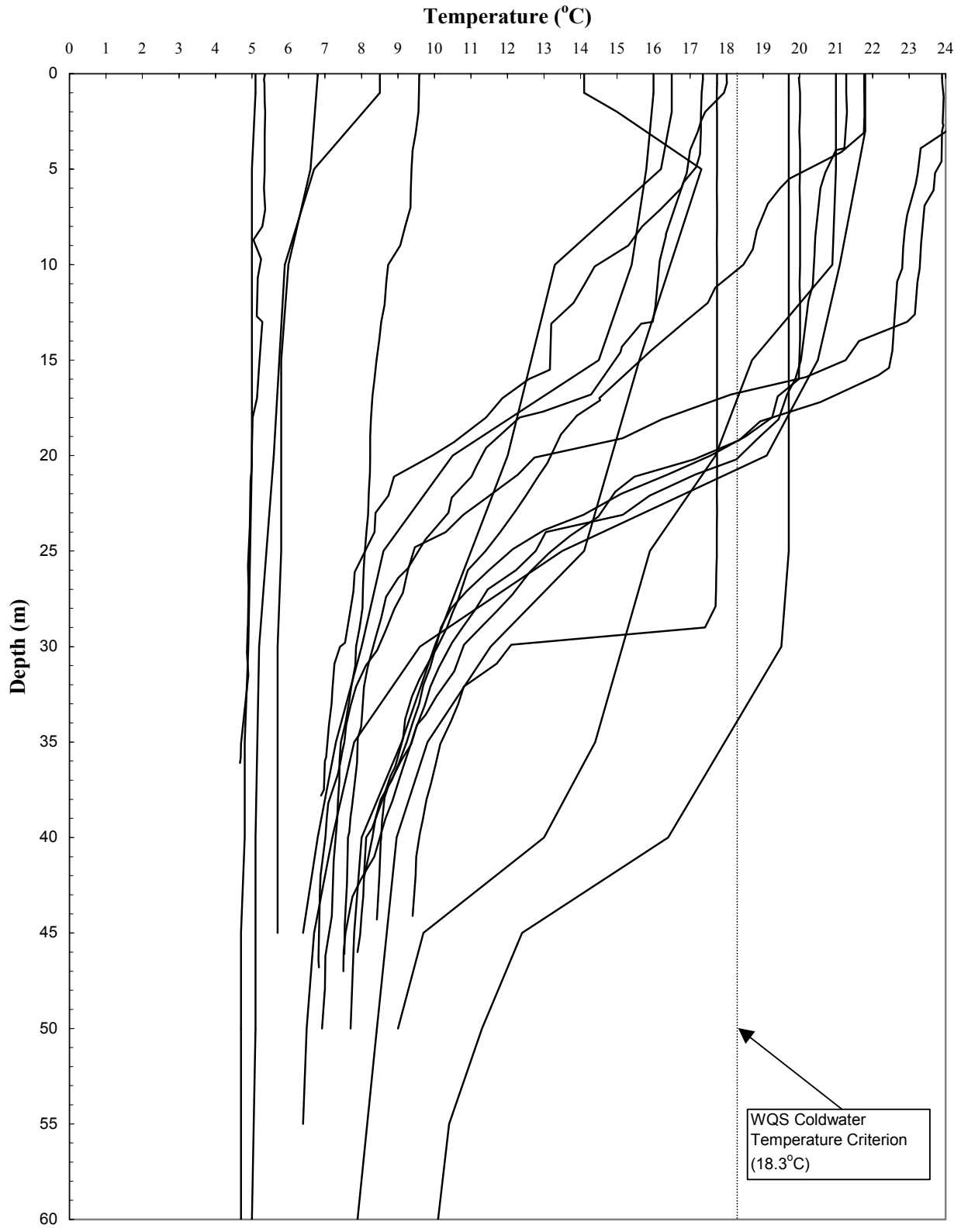
b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

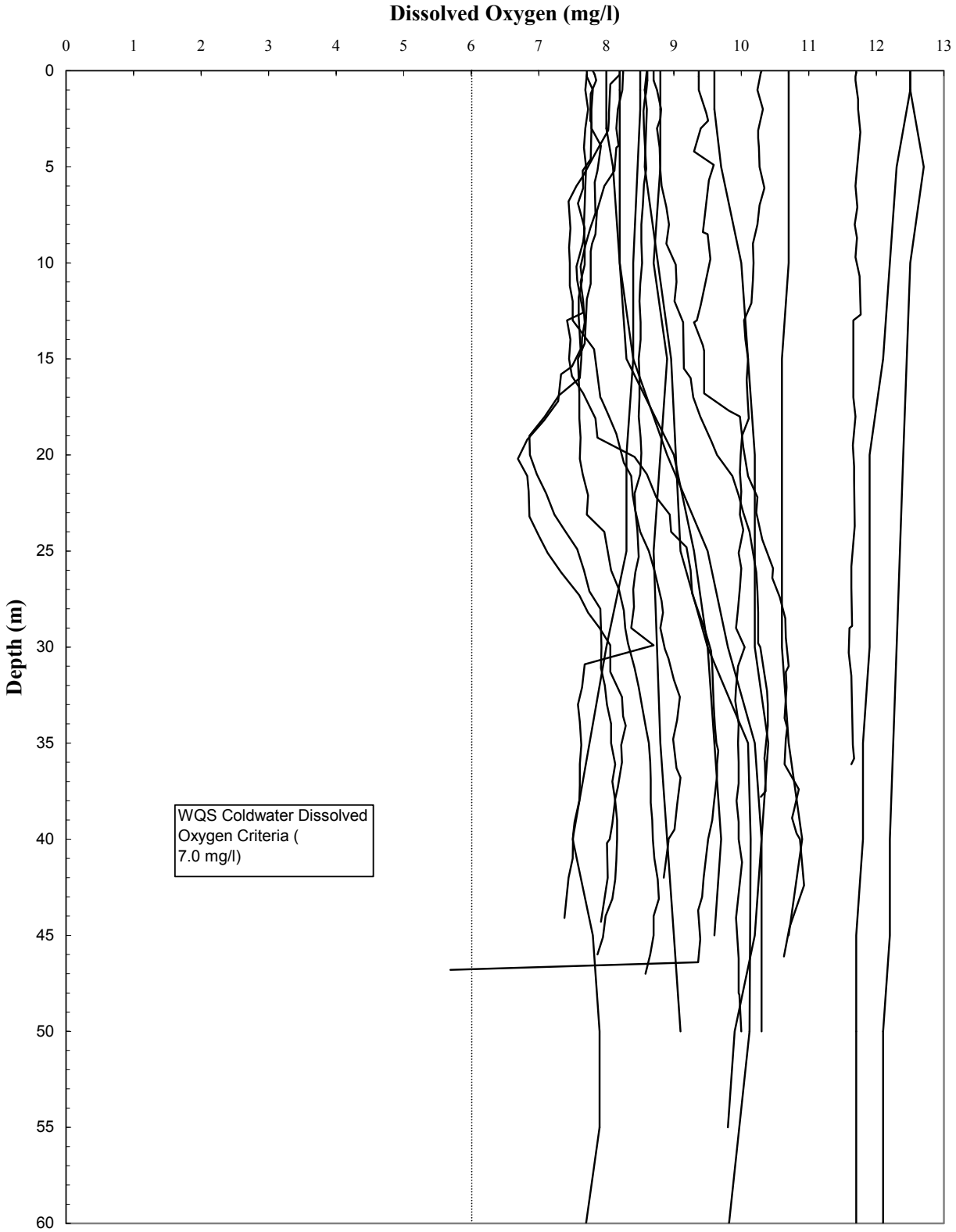
** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[(4)] Domestic drinking water supply.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.14. Temperature Depth Profiles for Lake Oahe Generated from Data Collected at the Long-Term In-Lake Fixed Monitoring Station during the 5-Year Period 1999-2003.



Appendix A.15. Dissolved Oxygen Depth Profiles for Lake Oahe Generated from Data Collected at the Long-term Fixed In-lake Monitoring Station during the 5-Year Period 1999-2003.



Appendix A.16. Summary of Water Quality Conditions Monitored in Lake Sharpe at the Deepwater, Near-dam Location during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	0.1	112	19.7	19.5	13.1	26.4	≤ 18.3	86	77%
Dissolved Oxygen (mg/l)	0.1	112	8.1	8.6	5.5	10.3	≥ 6.0 ≥ 7.0	9 32	8% 29%
Dissolved Oxygen (% Sat.)	0.1	112	91.4	94.9	65.9	107.7	-----	-----	-----
Specific Conductance (umho/cm)	1	112	726	722	103	747	-----	-----	-----
pH (S.U.)	0.1	112	-----	8.3	8.0	8.4	≥6.6 & ≤8.6	0	0%
Turbidity (NTUs)	0.1	88	3.0	2.4	n.d.	7.6	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	91	345	357	298	374	-----	-----	-----
Secchi Depth (in.)	1	4	121	112	63	196	-----	-----	-----
Alkalinity, Total (mg/l)	7	10	179	176	166	198	-----	-----	-----
Ammonia, Total (mg/l)	0.01	10	0.17	0.09	n.d.	0.48	≤ 0.5[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	11	-----	0.2	n.d.	0.6	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	n.d.	≤ 10	0	0%
Hardness, Total (mg/l)	0.4	2	324	324	246	401	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.09	0.02	n.d.	0.47	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	10	-----	n.d.	n.d.	0.01	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	-----	n.d.	n.d.	5	≤ 53	0	0%
Total Organic Carbon (mg/l)	0.05	10	3.3	3.1	3.0	3.8	-----	-----	-----
Chlorophyll *a* (ug/l)	1	3	2	2	1	2	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	360[(2)] 190[(3)] 18[(4)]	0 0 0	0% 0% 0%
Beryllium, Dissolved (ug/l)	4	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	9.6[(2)] 2.0[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,137[(2)] 367[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	39.1[(2)] 24.2[(3)] 1,300[(4)]	0 0 0	0% 0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	166.6[(2)] 6.5[(3)]	0 0	0% 0%
Thallium, Dissolved, (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1.7[(4)]	b.d.	-----
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	2,989[(2)] 332[(3)] 610[(4)]	0 0 0	0% 0% 0%
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	15.8[(2)]	0	0%
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	14[(4)]	b.d.	-----
Selenium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	2.1[(2)] 0.012[(3)] 0.14[(4)]	0 b.d. b.d	0% ----- -----
Atrazine, Total (ug/l)	0.05	5	-----	0.06	n.d.	0.08	-----	-----	-----
Metolachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Alachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[(4)] Domestic drinking water supply.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.17. Summary of Water Quality Conditions Monitored in the Big Bend Dam Tailwaters during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	0.1	5	21.2	20.7	14.8	26.1	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	5	8.2	8.6	7.0	9.8	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	5	96.0	96.4	88.5	105.6	-----	-----	-----
Specific Conductance (umho/cm)	1	5	728	722	706	753	-----	-----	-----
pH (S.U.)	0.1	5	-----	8.3	7.6	8.4	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	4	15.0	11.2	2.9	34.8	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	4	337	341	295	270	-----	-----	-----
Alkalinity, Total (mg/l)	7	5	177	171	169	192	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	0.26	0.33	n.d.	0.48	≤ 1.0[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	6	-----	0.4	n.d.	0.7	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	5	-----	n.d	n.d	n.d	≤ 10	0	0%
Hardness, Total (mg/l)	0.4	1	251	251	251	251	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	5	0.05	0.04	0.02	0.07	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	5	-----	n.d	n.d	n.d	-----	-----	-----
Suspended Solids, Total (mg/l)	4	5	-----	7	n.d.	16	≤ 90	0	0%
Total Organic Carbon (mg/l)	0.05	5	3.2	3.1	3.0	3.3	-----	-----	-----
Chlorophyll *a* (ug/l)	1	4	2	2	1	3	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	360[(2)] 190[(3)] 18[(4)]	0 0 0	0% 0% 0%
Beryllium, Dissolved (ug/l)	4	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	9.6[(2)] 2.0[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,137[(2)] 367[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	39.1[(2)] 24.2[(3)] 1,300[(4)]	0 0 0	0% 0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	166.6[(2)] 6.5[(3)]	0 0	0% 0%
Thallium, Dissolved, (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1.7[(4)]	b.d.	-----
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	2,989[(2)] 332[(3)] 610[(4)]	0 0 0	0% 0% 0%
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	15.8[(2)]	0	0%
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	14[(4)]	b.d.	-----
Selenium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	2.1[(2)] 0.012[(3)] 0.14[(4)]	0 b.d. b.d	0% ----- -----
Atrazine, Total (ug/l)	0.05	5	-----	0.07	n.d.	0.08	-----	-----	-----
Metolachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Alachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

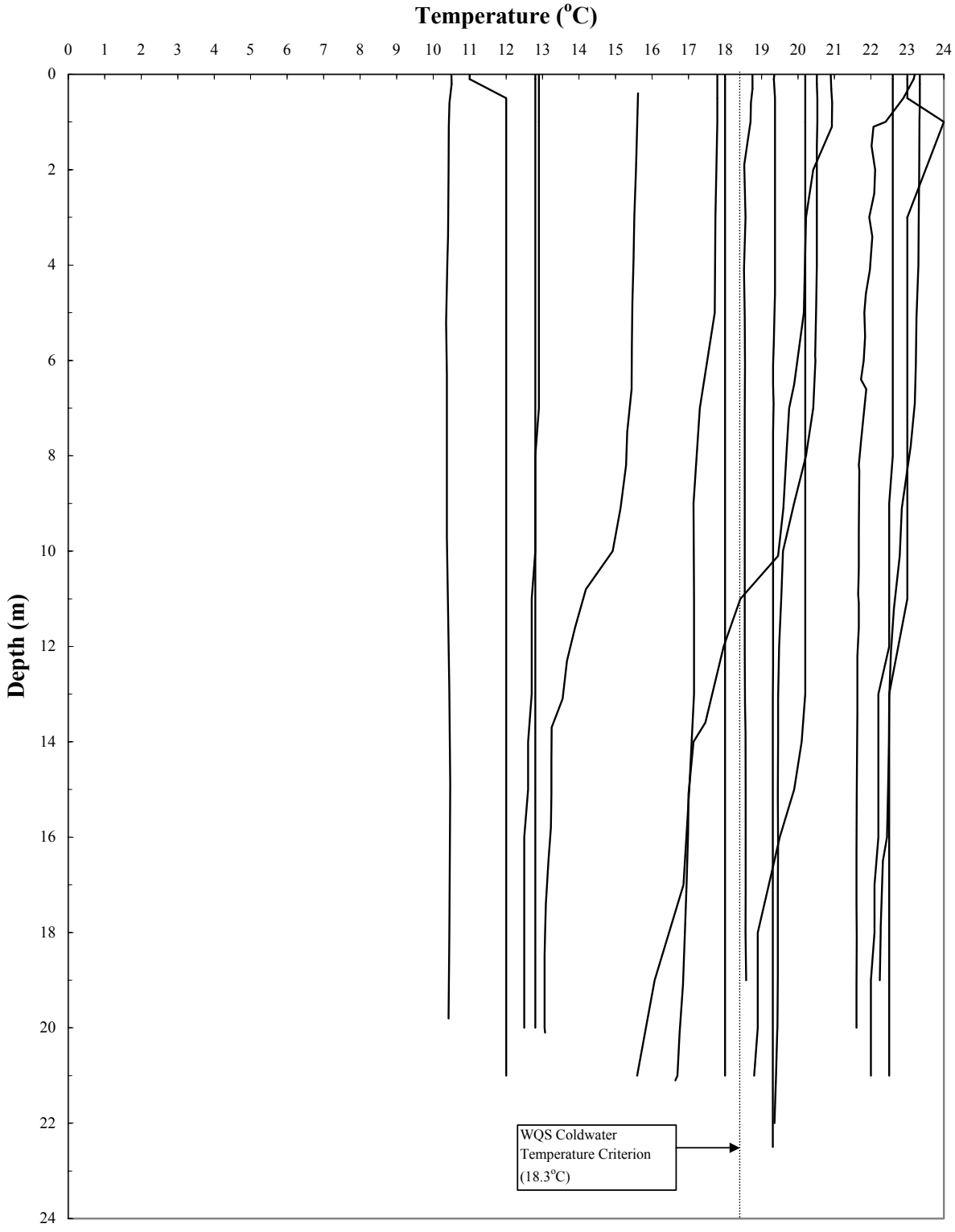
b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

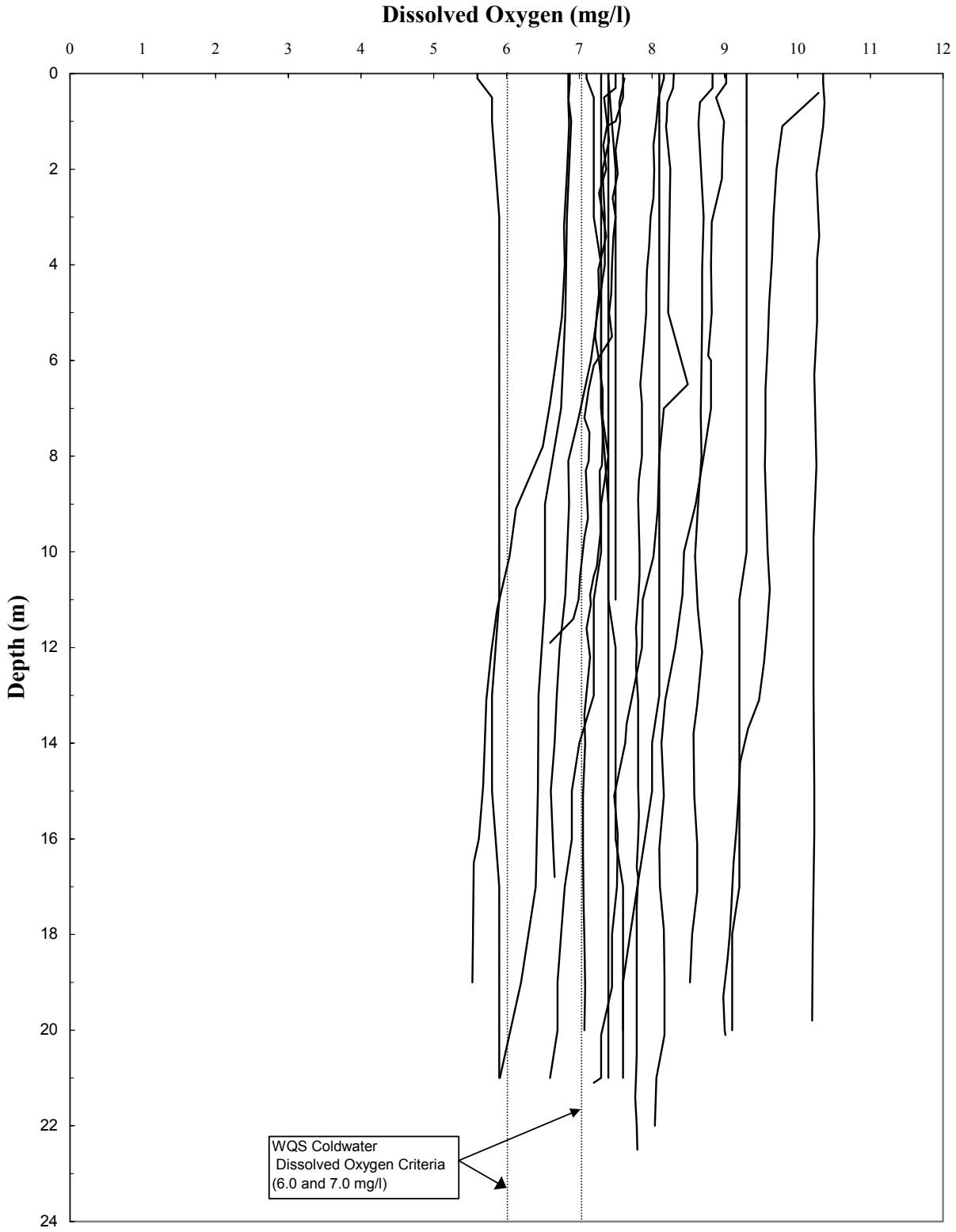
** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[(4)] Domestic drinking water supply.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.18. Temperature Depth Profiles for Lake Sharpe Generated from Data Collected at the Long-Term In-Lake Fixed Monitoring Station During the 5-Year Period 1999-2003.



Appendix A.19. Dissolved Oxygen Depth Profiles for Lake Sharpe Generated from Data Collected at the Long-term Fixed In-lake Monitoring Station during the 5-Year Period 1999-2003.



Appendix A.20. Summary of Water Quality Conditions Monitored in Lake Francis Case at the Deepwater, Near-dam Location during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	0.1	182	18.1	20.8	5.6	25.4	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	182	8.8	8.2	2.9	12.8	≥ 5.0	6	3%
Dissolved Oxygen (% Sat.)	0.1	182	92.7	94.1	34.3	108.4	-----	-----	-----
Specific Conductance (umho/cm)	1	182	736	738	704	759	-----	-----	-----
pH (S.U.)	0.1	182	-----	8.2	5.9	8.4	≥6.5 & ≤9.0	27	15%
Turbidity (NTUs)	0.1	145	2.4	2.3	0.2	6.9	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	182	377	384	301	441	-----	-----	-----
Secchi Depth (in.)	1	6	142	134	108	216	-----	-----	-----
Alkalinity, Total (mg/l)	7	12	175	174	163	191	-----	-----	-----
Ammonia, Total (mg/l)	0.01	12	0.32	0.21	n.d.	1.3	≤ 1.2[(1)]	1	8%
Kjeldahl N, Total (mg/l)	0.1	12	0.5	0.4	n.d.	2.2	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	12	-----	n.d.	n.d.	0.07	≤ 10	0	0%
Hardness, Total (mg/l)	0.4	6	246	239	230	280	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	12	-----	0.02	n.d.	0.04	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	12	-----	n.d.	n.d.	n.d.	-----	-----	-----
Suspended Solids, Total (mg/l)	4	12	-----	n.d.	n.d.	n.d.	≤ 90	0	0%
Total Organic Carbon (mg/l)	0.05	12	3.1	3.2	2.9	3.3	-----	-----	-----
Chlorophyll *a* (ug/l)	1	5	-----	1	n.d.	2	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	360[(2)] 190[(3)] 18[(4)]	0 0 0	0% 0% 0%
Beryllium, Dissolved (ug/l)	4	2	-----	n.d.	n.d.	n.d.	-----	-----	-----
Cadmium, Dissolved (ug/l)	3	2	-----	n.d.	n.d.	n.d.	9.6[(2)] 2.0[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	1,137[(2)] 367[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	2	-----	n.d.	n.d.	n.d.	39.1[(2)] 24.2[(3)] 1,300[(4)]	0 0 0	0% 0% 0%
Lead, Dissolved (ug/l)	5	2	-----	n.d.	n.d.	n.d.	166.6[(2)] 6.5[(3)]	0 0	0% 0%
Thallium, Dissolved, (ug/l)	10	2	-----	n.d.	n.d.	n.d.	1.7[(4)]	b.d.	-----
Nickel, Dissolved (ug/l)	40	2	-----	n.d.	n.d.	n.d.	2,989[(2)] 332[(3)] 610[(4)]	0 0 0	0% 0% 0%
Silver, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	15.8[(2)]	0	0%
Antimony, Dissolved (ug/l)	20	2	-----	n.d.	n.d.	n.d.	14[(4)]	b.d.	-----
Selenium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Selenium, Total (ug/l)	10	2	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Dissolved (ug/l)	0.2	2	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.2	2	-----	n.d.	n.d.	n.d.	2.1[(2)] 0.012[(3)] 0.14[(4)]	0 b.d. b.d	0% ----- -----
Atrazine, Total (ug/l)	0.05	6	-----	n.d.	n.d.	0.08	-----	-----	-----
Metolachlor (ug/l)	0.05	6	-----	n.d.	n.d.	n.d.	-----	-----	-----
Alachlor (ug/l)	0.05	6	-----	n.d.	n.d.	n.d.	-----	-----	-----
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[(4)] Domestic drinking water supply.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.21. Summary of Water Quality Conditions Monitored in the Fort Randall Dam Tailwaters during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	0.1	13	15.5	17.0	4.7	23.8	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	13	8.9	8.6	6.6	12.8	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	13	90.9	92.6	77.9	104.6	-----	-----	-----
Specific Conductance (umho/cm)	1	13	742	746	698	770	-----	-----	-----
pH (S.U.)	0.1	13	-----	8.3	8.1	8.7	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	11	6.3	5.3	1.2	21.6	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	10	390	383	334	466	-----	-----	-----
Alkalinity, Total (mg/l)	7	12	175	177	156	185	-----	-----	-----
Ammonia, Total (mg/l)	0.01	12	0.18	0.16	n.d.	0.43	≤ 1.2[(1)]	0	0
Kjeldahl N, Total (mg/l)	0.1	12	-----	0.1	n.d.	0.6	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	12	-----	n.d.	n.d.	0.03	≤ 10	0	0%
Phosphorus, Total (mg/l)	0.01	12	-----	0.04	n.d.	0.59	-----	-----	-----
Suspended Solids, Total (mg/l)	4	12	-----	n.d.	n.d.	5.5	≤ 90	0	0%
Total Organic Carbon (mg/l)	0.05	12	3.2	3.2	3.0	3.6	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	12	8	8	4	12	-----	-----	-----
Chloride (mg/l)	0.02	12	10.1	9.7	9.1	12.0	-----	-----	-----
Hardness, Total (mg/l)	0.4	2	239	239	236	241	-----	-----	-----
Calcium, Dissolved (mg/l)	0.1	2	56.1	56.1	56.0	56.1	-----	-----	-----
Magnesium, Dissolved (mg/l)	0.04	2	23.8	23.8	23.0	24.5	-----	-----	-----
Sodium, Dissolved (mg/l)	0.2	2	72.2	72.2	67.3	77.0	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	360[(2)] 190[(3)] 18[(4)]	0 0 0	0% 0% 0%
Cadmium, Dissolved (ug/l)	3	2	-----	n.d.	n.d.	n.d.	9.6[(2)] 2.0[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	1,137[(2)] 367[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	2	-----	n.d.	n.d.	n.d.	39.1[(2)] 24.2[(3)] 1,300[(4)]	0 0 0	0% 0% 0%
Lead, Dissolved (ug/l)	5	2	-----	n.d.	n.d.	n.d.	166.6[(2)] 6.5[(3)]	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	2	-----	n.d.	n.d.	n.d.	2,989[(2)] 332[(3)] 610[(4)]	0 0 0	0% 0% 0%
Silver, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	15.8[(2)]	0	0%
Selenium, Total (ug/l)	10	2	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Dissolved (ug/l)	0.2	2	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.2	2	-----	n.d.	n.d.	n.d.	2.1[(2)] 0.012[(3)] 0.14[(4)]	0 b.d. b.d	0% ----- -----
Atrazine, Total (ug/l)	0.05	12	-----	0.08	n.d..	1.26	-----	-----	-----
Metolachlor (ug/l)	0.05	12	-----	n.d.	n.d.	n.d.	-----	-----	-----
Alachlor (ug/l)	0.05	12	-----	n.d.	n.d.	n.d.	-----	-----	-----
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

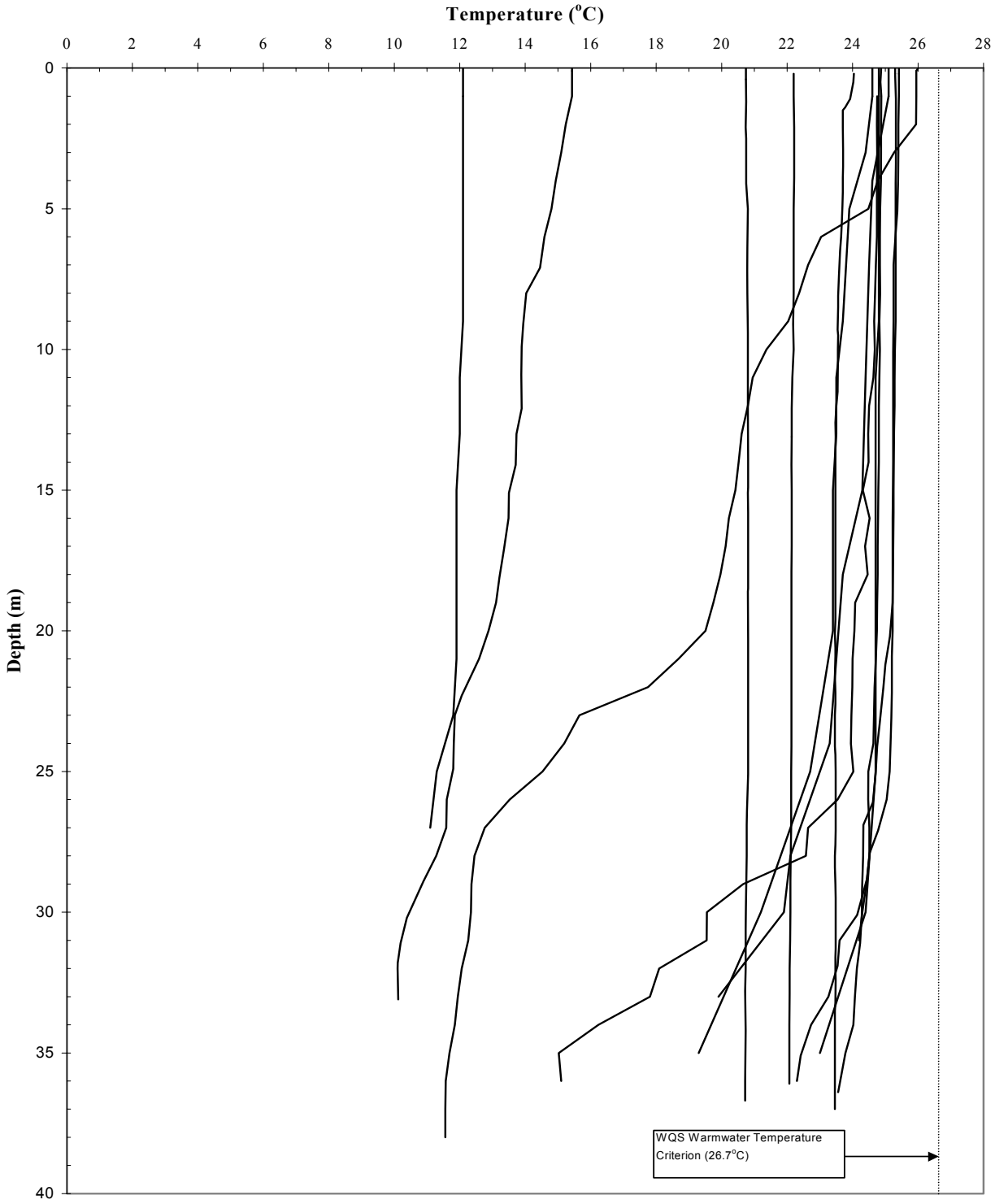
b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

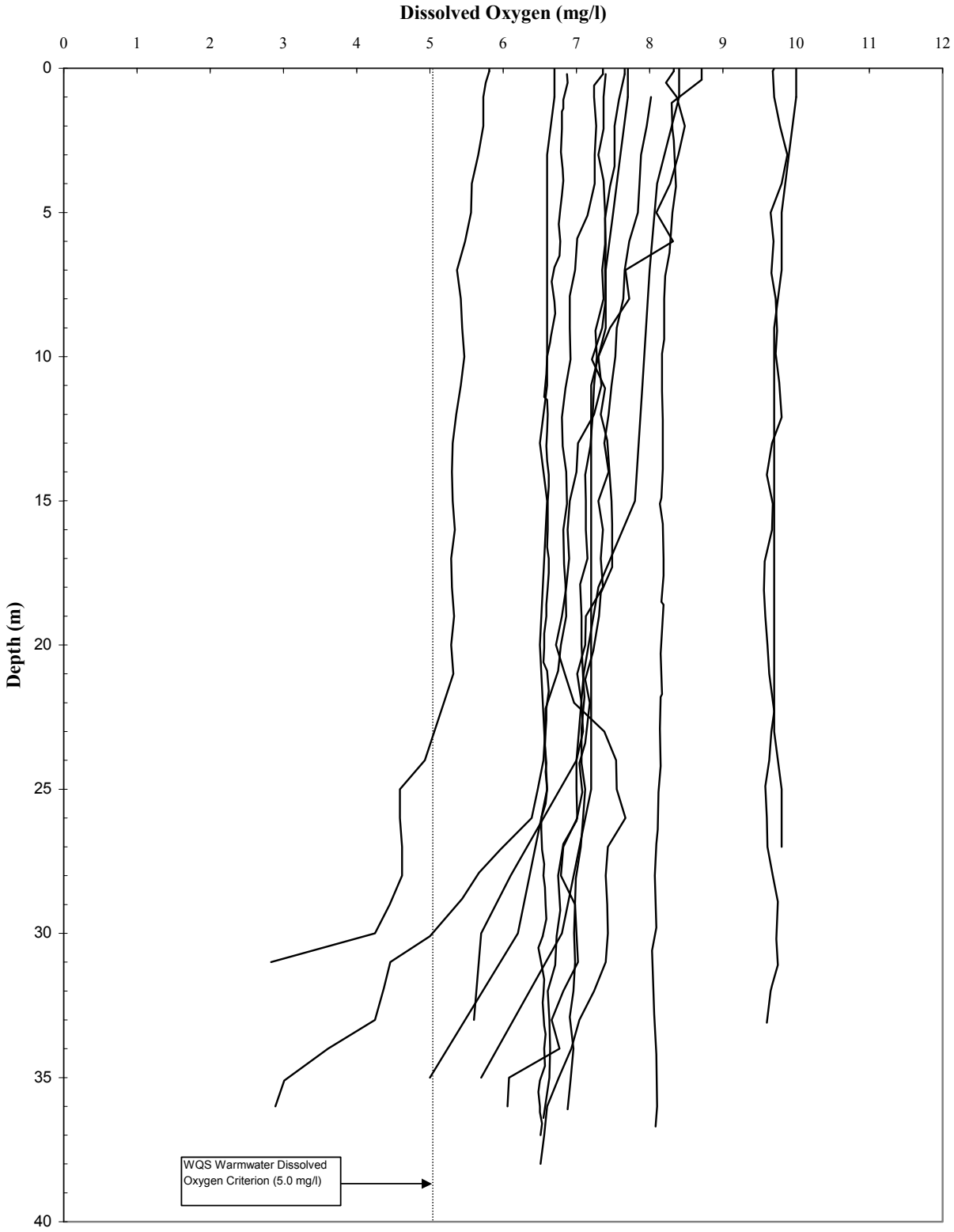
** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[(4)] Domestic drinking water supply.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.22. Temperature Depth Profiles for Lake Francis Case Generated from Data Collected at the Long-Term In-Lake Fixed Monitoring Station During the 5-Year Period 1999-2003.



Appendix 23. Dissolved Oxygen Depth Profiles for Lake Francis Case Generated from Data Collected at the Long-Term In-Lake Monitoring Station during the 5-Year Period 1999-2003.



Appendix A.24. Summary of Water Quality Conditions Monitored in Lewis and Clark Lake at the Deepwater, Near-dam Location during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	0.1	43	19.6	17.0	10.6	26.6	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	43	8.3	8.3	5.1	11.6	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	43	91.0	91.4	63.6	111.1	-----	-----	-----
Specific Conductance (umho/cm)	1	43	720	692	686	755	-----	-----	-----
pH (S.U.)	0.1	43	-----	8.4	8.1	8.5	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	10	3.0	2.9	2.6	3.7	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	32	425	428	407	437	-----	-----	-----
Secchi Depth (in.)	1	5	39	36	26	66	-----	-----	-----
Alkalinity, Total (mg/l)	7	10	173	174	162	182	-----	-----	-----
Ammonia, Total (mg/l)	0.01	9	0.22	0.09	n.d.	0.46	≤ 0.7[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	0.32	0.25	n.d.	0.62	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	0.04	≤ 10	0	0%
Hardness, Total (mg/l)	0.4	6	234	238	218	245	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	-----	0.02	n.d.	0.07	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	10	-----	n.d.	n.d.	n.d.	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	7	8	n.d.	21	≤ 90	0	0%
Total Organic Carbon (mg/l)	0.05	10	3.2	3.3	3.0	3.4	-----	-----	-----
Chlorophyll *a* (ug/l)	1	4	7	7	5	10	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	360[(2)] 190[(3)] 18[(4)]	0 0 0	0% 0% 0%
Beryllium, Dissolved (ug/l)	4	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	9.6[(2)] 2.0[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,137[(2)] 367[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	39.1[(2)] 24.2[(3)] 1,300[(4)]	0 0 0	0% 0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	166.6[(2)] 6.5[(3)]	0 0	0% 0%
Thallium, Dissolved, (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1.7[(4)]	b.d.	-----
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	2,989[(2)] 332[(3)] 610[(4)]	0 0 0	0% 0% 0%
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	15.8[(2)]	0	0%
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	14[(4)]	b.d.	-----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	2.1[(2)] 0.012[(3)] 0.14[(4)]	0 b.d. b.d	0% ----- -----
Atrazine, Total (ug/l)	0.05	5	0.13	0.09	0.06	0.32	-----	-----	-----
Metolachlor (ug/l)	0.05	5	-----	n.d.	n.d.	0.11	-----	-----	-----
Alachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[(4)] Domestic drinking water supply.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.25. Summary of Water Quality Conditions Monitored in the Gavins Point Dam Tailwaters during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Water Temperature (°C)	0.1	13	17.7	18.1	5.3	26.1	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	13	8.9	8.9	6.5	11.2	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	13	94.7	94.3	82.9	109.0	-----	-----	-----
Specific Conductance (umho/cm)	1	13	718	721	680	756	-----	-----	-----
pH (S.U.)	0.1	13	-----	8.4	8.0	9.0	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	11	19.2	12.2	5.6	64.0	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	10	381	386	337	428	-----	-----	-----
Alkalinity, Total (mg/l)	7	12	175	173	161	215	-----	-----	-----
Ammonia, Total (mg/l)	0.01	12	-----	0.08	n.d.	0.43	≤ 0.7[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	12	-----	n.d.	n.d.	0.58	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	12	-----	n.d.	n.d.	0.09	≤ 10	0	0%
Phosphorus, Total (mg/l)	0.01	12	0.03	0.03	n.d.	0.08	-----	-----	-----
Suspended Solids, Total (mg/l)	4	12	11	11	n.d.	31	≤ 90	0	0%
Total Organic Carbon (mg/l)	0.05	12	3.3	3.3	3.0	3.4	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	12	7	6	n.d.	14	-----	-----	-----
Chloride (mg/l)	0.02	12	9.6	9.3	8.5	11.0	-----	-----	-----
Hardness, Total (mg/l)	0.4	2	69.4	69.4	64.8	74.0	-----	-----	-----
Calcium, Dissolved (mg/l)	0.1	2	238	238	232	244	-----	-----	-----
Magnesium, Dissolved (mg/l)	0.04	2	57	57	56	58	-----	-----	-----
Sodium, Dissolved (mg/l)	0.2	2	24	24	23	24	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	360[(2)] 190[(3)] 18[(4)]	0 0 0	0% 0% 0%
Cadmium, Dissolved (ug/l)	3	2	-----	n.d.	n.d.	n.d.	9.6[(2)] 2.0[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	1,137[(2)] 367[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	2	-----	n.d.	n.d.	n.d.	39.1[(2)] 24.2[(3)] 1,300[(4)]	0 0 0	0% 0% 0%
Lead, Dissolved (ug/l)	5	2	-----	n.d.	n.d.	n.d.	166.6[(2)] 6.5[(3)]	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	2	-----	n.d.	n.d.	n.d.	2,989[(2)] 332[(3)] 610[(4)]	0 0 0	0% 0% 0%
Silver, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	15.8[(2)]	0	0%
Zinc, Dissolved (ug/l)	20	2	-----	n.d.	n.d.	n.d.	84.6[(2)] 77.3[(3)]	0 0	0% 0%
Selenium, Total (ug/l)	10	2	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Mercury, Dissolved (ug/l)	0.2	2	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.2	2	-----	n.d.	n.d.	n.d.	2.1[(2)] 0.012[(3)] 0.14[(4)]	0 b.d. b.d	0% ----- -----
Atrazine, Total (ug/l)	0.05	12	-----	0.07	n.d..	0.15	-----	-----	-----
Metolachlor (ug/l)	0.05	12	-----	n.d.	n.d.	0.13	-----	-----	-----
Alachlor (ug/l)	0.05	12	-----	n.d.	n.d.	n.d.	-----	-----	-----
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

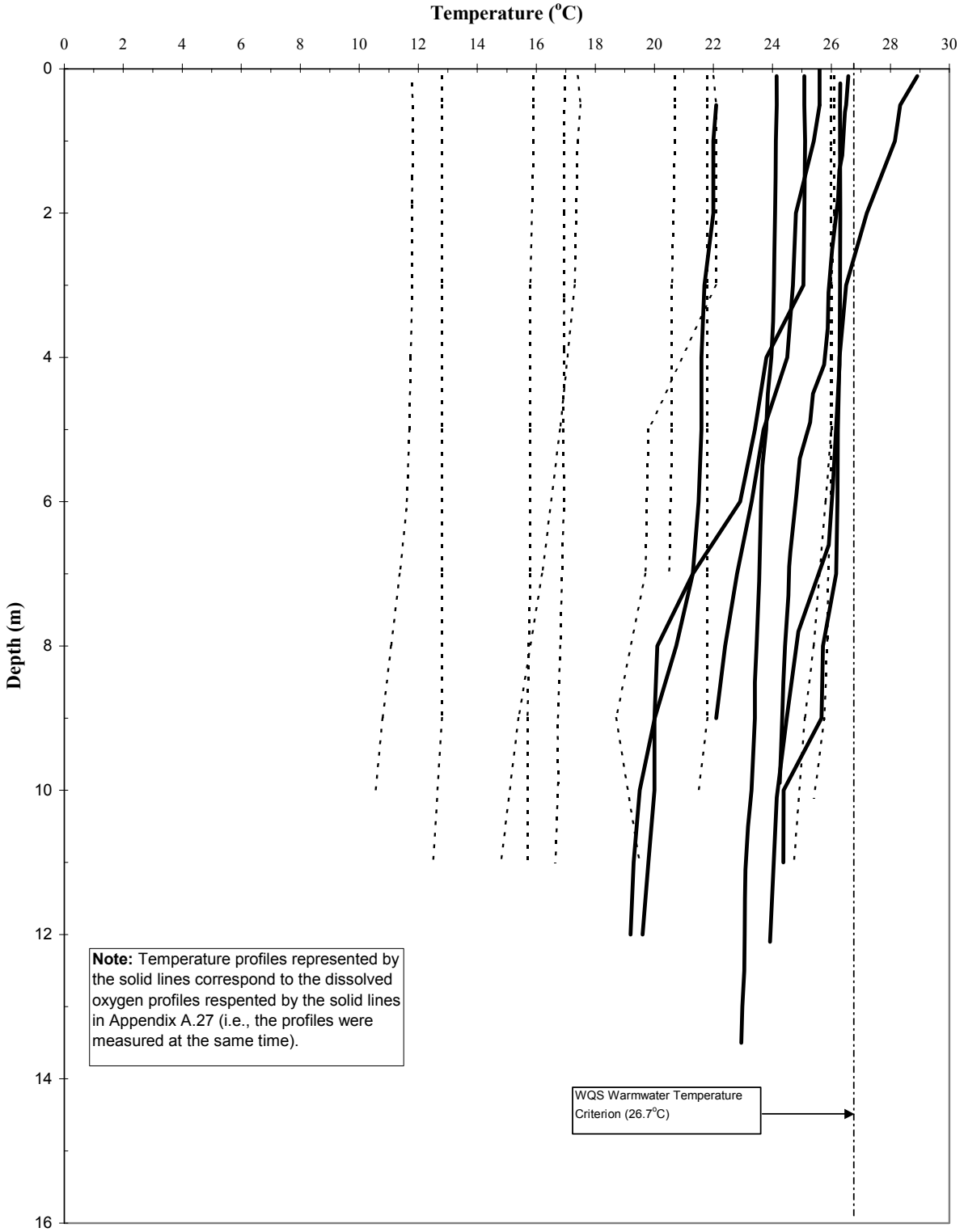
b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

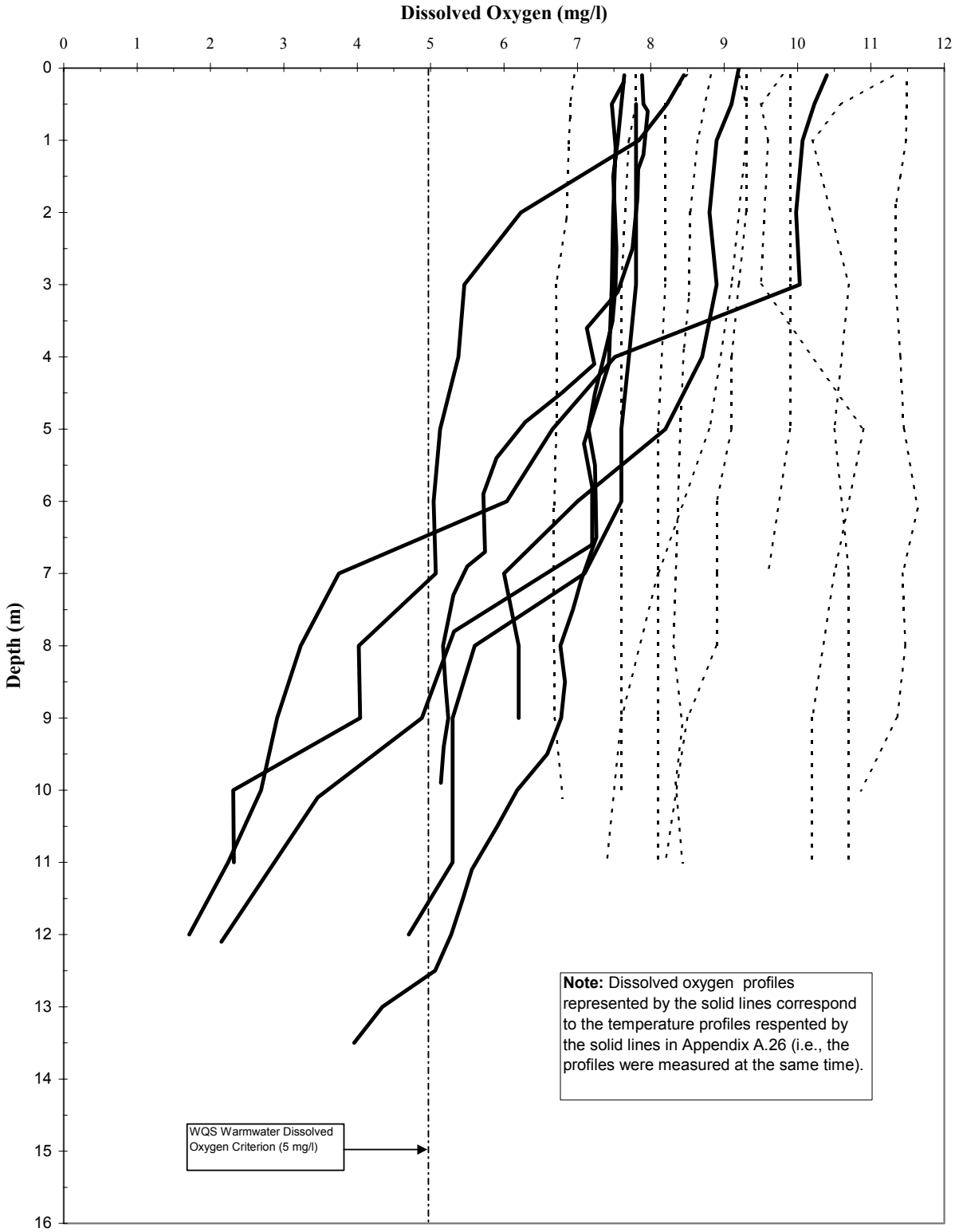
** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[(4)] Domestic drinking water supply.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.26. Temperature Depth Profiles for Lewis and Clark Lake Generated from Data Collected at the Long-Term In-Lake Fixed Monitoring Station during the 5-Year Period 1999-2003.



Appendix A.27. Dissolved Oxygen Depth Profiles for Lewis and Clark Lake Generated from Data Collected at the Long-Term In-Lake Monitoring Station during the 5-Year Period 1999-2003.



Appendix A.28. Summary of Water Quality Conditions Monitored in the Missouri River near Verdel, Nebraska (RM 851) during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Stream Flow (cfs)	-----	13	27,120	27,000	22,000	37,000	-----	-----	-----
Water Temperature (°C)	0.1	14	16.9	16.9	6.9	24.8	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	14	9.0	9.1	6.9	12.3	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	14	95.1	96.0	83.2	113.1	-----	-----	-----
Specific Conductance (umho/cm)	1	14	743	752	695	770	-----	-----	-----
pH (S.U.)	0.1	14	-----	8.3	8.0	9.1	≥6.5 & ≤9.0	1	7%
Turbidity (NTUs)	0.1	12	7.5	8.0	2.4	17.5	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	11	382	384	336	445	-----	-----	-----
Alkalinity, Total (mg/l)	7	13	175	175	157	188	-----	-----	-----
Ammonia, Total (mg/l)	0.01	13	-----	0.10	n.d.	0.59	≤ 3.0[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	13	-----	0.4	n.d.	0.8	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	13	-----	n.d.	n.d.	0.04	≤ 10	0	0%
Phosphorus, Total (mg/l)	0.01	13	-----	0.01	n.d.	0.07	-----	-----	-----
Suspended Solids, Total (mg/l)	4	13	-----	6	n.d.	10	≤ 90	0	0%
Total Organic Carbon (mg/l)	0.05	13	3.2	3.2	2.9	3.5	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	13	7	8	2	8	-----	-----	-----
Chloride (mg/l)	0.02	13	10.0	9.6	8.8	12.0	≤ 860	0	0%
Hardness, Total (mg/l)	0.4	2	239	239	236	242	-----	-----	-----
Calcium, Dissolved (mg/l)	0.1	3	54	55	52	57	-----	-----	-----
Magnesium, Dissolved (mg/l)	0.04	3	23	23	23	25	-----	-----	-----
Sodium, Dissolved (mg/l)	0.2	3	72	74	67	76	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	340[(2)] 16.7[(3)]	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	3	-----	n.d.	n.d.	n.d.	4.70[(2)] 0.45[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	1,167[(2)] 152[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	30.6[(2)] 18.9[(3)]	0 0	0% 0%
Lead, Dissolved (ug/l)	5	3	-----	n.d.	n.d.	n.d.	165.0[(2)] 6.4[(3)]	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	3	-----	n.d.	n.d.	n.d.	982[(2)] 109[(3)]	0 0	0% 0%
Silver, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	15.6[(2)]	0	0%
Zinc, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	246[(2)(3)]	0	0%
Selenium, Total (ug/l)	10	3	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Mercury, Dissolved (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	1.4[(2)]	0	0%
Mercury, Total (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	0.051[(3)]	b.d	-----
Atrazine, Total (ug/l)	0.05	13	-----	0.06	n.d.	0.18	330[(2)] 12[(3)]	0 0	0% 0%
Metolachlor (ug/l)	0.05	13	-----	n.d.	n.d.	0.06	390[(2)] 100[(3)]	0 0	0% 0%
Alachlor (ug/l)	0.05	13	-----	n.d.	n.d.	n.d.	760[(2)] 76[(3)]	0 0	0% 0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.29. Summary of Water Quality Conditions Monitored in the Missouri River near Maskell, Nebraska (RM 774) during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Stream Flow (cfs)	-----	13	26,589	26,343	24,450	30,600	-----	-----	-----
Water Temperature (°C)	0.1	14	18.5	19.3	4.1	26.4	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	14	8.8	8.8	7.1	11.6	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	14	96.3	97.5	90.7	101.4	-----	-----	-----
Specific Conductance (umho/cm)	1	14	723	720	690	766	-----	-----	-----
pH (S.U.)	0.1	14	-----	8.4	8.1	9.0	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	12	58.3	16.7	6.1	352.7	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	11	375	379	336	431	-----	-----	-----
Alkalinity, Total (mg/l)	7	13	173	173	135	218	-----	-----	-----
Ammonia, Total (mg/l)	0.01	13	-----	0.15	n.d.	0.68	≤ 3.0(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	13	0.3	0.3	n.d.	0.9	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	13	-----	n.d.	n.d.	0.12	≤ 10	0	0%
Phosphorus, Total (mg/l)	0.01	13	0.08	0.04	n.d.	0.37	-----	-----	-----
Suspended Solids, Total (mg/l)	4	13	51	18	8	320	≤ 90	2	15%
Total Organic Carbon (mg/l)	0.05	13	3.3	3.3	3.0	3.8	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	13	10	9	4	27	-----	-----	-----
Chloride (mg/l)	0.02	13	9.8	9.5	8.6	11.0	≤ 860	0	0%
Hardness, Total (mg/l)	0.4	2	245	245	238	252	-----	-----	-----
Calcium, Dissolved (mg/l)	0.1	3	56	55	54	60	-----	-----	-----
Magnesium, Dissolved (mg/l)	0.04	3	24	24	22	25	-----	-----	-----
Sodium, Dissolved (mg/l)	0.2	3	71	72	65	75	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	340(2) 16.7(3)	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	3	-----	n.d.	n.d.	n.d.	4.70(2) 0.45(3)	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	1,167(2) 152(3)	0 0	0% 0%
Copper, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	30.6(2) 18.9(3)	0 0	0% 0%
Lead, Dissolved (ug/l)	5	3	-----	n.d.	n.d.	n.d.	165.0(2) 6.4(3)	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	3	-----	n.d.	n.d.	n.d.	982(2) 109(3)	0 0	0% 0%
Silver, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	15.6(2)	0	0%
Zinc, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	246(2)(3)	0	0%
Selenium, Total (ug/l)	10	3	-----	n.d.	n.d.	n.d.	20(2) 5(3)	0 b.d.	0% -----
Mercury, Dissolved (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	1.4(2)	0	0%
Mercury, Total (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	0.051(3)	b.d	-----
Atrazine, Total (ug/l)	0.05	13	-----	0.09	n.d.	1.02	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	13	-----	n.d.	n.d.	0.41	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	13	-----	n.d.	n.d.	0.06	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** (1)Total ammonia criterion pH and temperature dependent.

(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)

(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.30. Summary of Water Quality Conditions Monitored in the Missouri River near Ponca, Nebraska (RM 753) during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Stream Flow (cfs)	-----	11	27,101	26,447	24,738	30,650	-----	-----	-----
Water Temperature (°C)	0.1	12	18.8	20.26	4.1	26.7	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	12	8.7	8.3	7.6	11.6	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	12	95.8	94.6	90.4	101.8	-----	-----	-----
Specific Conductance (umho/cm)	1	12	728	730	683	785	-----	-----	-----
pH (S.U.)	0.1	12	-----	8.4	8.1	9.0	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	10	164.7	20.6	8.3	945.4	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	9	374	377	334	422	-----	-----	-----
Alkalinity, Total (mg/l)	7	11	169	172	127	210	-----	-----	-----
Ammonia, Total (mg/l)	0.01	11	-----	0.09	n.d.	0.45	≤ 3.0[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	11	0.6	0.5	n.d.	2.2	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	11	-----	n.d.	n.d.	0.23	≤ 10	0	0%
Phosphorus, Total (mg/l)	0.01	11	0.14	0.04	n.d.	0.73	-----	-----	-----
Suspended Solids, Total (mg/l)	4	11	107	25	14	498	≤ 90	3	27%
Total Organic Carbon (mg/l)	0.05	11	3.5	3.4	3.0	4.3	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	11	16	11	3	56	-----	-----	-----
Chloride (mg/l)	0.02	11	10	10	9	11	≤ 860	0	0%
Hardness, Total (mg/l)	0.4	2	240	240	229	251	-----	-----	-----
Calcium, Dissolved (mg/l)	0.1	2	55	55	52	58	-----	-----	-----
Magnesium, Dissolved (mg/l)	0.04	2	24	24	24	24	-----	-----	-----
Sodium, Dissolved (mg/l)	0.2	2	70	70	66	74	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	340[(2)] 16.7[(3)]	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	3	-----	n.d.	n.d.	n.d.	4.70[(2)] 0.45[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	1,167[(2)] 152[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	30.6[(2)] 18.9[(3)]	0 0	0% 0%
Lead, Dissolved (ug/l)	5	3	-----	n.d.	n.d.	n.d.	165.0[(2)] 6.4[(3)]	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	3	-----	n.d.	n.d.	n.d.	982[(2)] 109[(3)]	0 0	0% 0%
Silver, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	15.6[(2)]	0	0%
Zinc, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	246[(2)(3)]	0	0%
Selenium, Total (ug/l)	10	3	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Mercury, Dissolved (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	1.4[(2)]	0	0%
Mercury, Total (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	0.051[(3)]	b.d	-----
Atrazine, Total (ug/l)	0.05	11	0.34	0.09	n.d.	1.47	330[(2)] 12[(3)]	0 0	0% 0%
Metolachlor (ug/l)	0.05	11	-----	n.d.	n.d.	0.70	390[(2)] 100[(3)]	0 0	0% 0%
Alachlor (ug/l)	0.05	11	-----	n.d.	n.d.	0.09	760[(2)] 76[(3)]	0 0	0% 0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.31. Summary of Water Quality Conditions Monitored in the Missouri River near Decatur, Nebraska (RM 691) during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Stream Flow (cfs)	-----	13	29,615	30,000	25,500	33,600	-----	-----	-----
Water Temperature (°C)	0.1	14	20.1	21.0	5.7	27.1	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	14	8.6	8.1	7.0	11.7	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	14	96.9	97.8	86.3	103.8	-----	-----	-----
Specific Conductance (umho/cm)	1	14	751	752	698	800	-----	-----	-----
pH (S.U.)	0.1	14	-----	8.3	8.1	8.8	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	12	82.9	30.3	13.0	396.9	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	11	368	366	335	417	-----	-----	-----
Alkalinity, Total (mg/l)	7	13	177	175	142	215	-----	-----	-----
Ammonia, Total (mg/l)	0.01	13	-----	0.10	n.d.	0.56	≤ 3.0[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	13	0.4	0.4	n.d.	0.8	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	13	0.34	0.39	0.03	0.87	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	13	0.14	0.08	0.03	0.48	-----	-----	-----
Suspended Solids, Total (mg/l)	4	13	95	41	27	455	-----	-----	-----
Total Organic Carbon (mg/l)	0.05	13	3.4	3.5	3.0	3.7	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	13	13	10	6	31	-----	-----	-----
Chloride (mg/l)	0.02	13	13	13	11	16	≤860	0	0%
Hardness, Total (mg/l)	0.4	2	251	251	236	265	-----	-----	-----
Calcium, Dissolved (mg/l)	0.1	3	57	54	53	64	-----	-----	-----
Magnesium, Dissolved (mg/l)	0.04	3	25	25	24	27	-----	-----	-----
Sodium, Dissolved (mg/l)	0.2	3	70	70	66	75	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	340[(2)] 16.7[(3)]	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	3	-----	n.d.	n.d.	n.d.	4.70[(2)] 0.45[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	1,167[(2)] 152[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	30.6[(2)] 18.9[(3)]	0 0	0% 0%
Lead, Dissolved (ug/l)	5	3	-----	n.d.	n.d.	n.d.	165.0[(2)] 6.4[(3)]	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	3	-----	n.d.	n.d.	n.d.	982[(2)] 109[(3)]	0 0	0% 0%
Silver, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	15.6[(2)]	0	0%
Zinc, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	246[(2)(3)]	0	0%
Selenium, Total (ug/l)	10	3	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Mercury, Dissolved (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	1.4[(2)]	0	0%
Mercury, Total (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	0.051[(3)]	b.d	-----
Atrazine, Total (ug/l)	0.05	13	0.25	0.12	n.d.	0.94	330[(2)] 12[(3)]	0 0	0% 0%
Metolachlor (ug/l)	0.05	13	-----	n.d.	n.d.	0.32	390[(2)] 100[(3)]	0 0	0% 0%
Alachlor (ug/l)	0.05	13	-----	n.d.	n.d.	0.43	760[(2)] 76[(3)]	0 0	0% 0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.32. Summary of Water Quality Conditions Monitored in the Missouri River near Omaha, Nebraska (RM 619) during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Stream Flow (cfs)	-----	13	32,538	30,000	24,800	42,500	-----	-----	-----
Water Temperature (°C)	0.1	14	20.0	20.6	6.6	27.9	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	14	80.	8.1	5.9	11.2	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	14	90.6	93.8	68.6	106.9	-----	-----	-----
Specific Conductance (umho/cm)	1	14	727	739	655	786	-----	-----	-----
pH (S.U.)	0.1	14	-----	8.3	7.8	8.6	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	12	367	58.2	35.7	1,798	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	11	368	370	309	411	-----	-----	-----
Alkalinity, Total (mg/l)	7	13	155	173	81	204	-----	-----	-----
Ammonia, Total (mg/l)	0.01	13	-----	0.12	n.d.	0.69	≤ 3.0[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	13	1.1	0.5	0.1	4.5	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	13	0.92	1.00	0.03	2.00	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	13	0.53	0.18	0.05	2.30	-----	-----	-----
Suspended Solids, Total (mg/l)	4	13	409	108	41	1,932	-----	-----	-----
Total Organic Carbon (mg/l)	0.05	13	3.7	3.4	3.0	5.1	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	13	28	12	4	141	-----	-----	-----
Chloride (mg/l)	0.02	13	12.8	13.0	11.0	16.0	≤860	0	0%
Hardness, Total (mg/l)	0.4	2	256	256	237	274	-----	-----	-----
Calcium, Dissolved (mg/l)	0.1	3	59	58	53	64	-----	-----	-----
Magnesium, Dissolved (mg/l)	0.04	3	25	25	24	26	-----	-----	-----
Sodium, Dissolved (mg/l)	0.2	3	66	66	65	68	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	340[(2)] 16.7[(3)]	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	3	-----	n.d.	n.d.	n.d.	4.70[(2)] 0.45[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	1,167[(2)] 152[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	30.6[(2)] 18.9[(3)]	0 0	0% 0%
Lead, Dissolved (ug/l)	5	3	-----	n.d.	n.d.	n.d.	165.0[(2)] 6.4[(3)]	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	3	-----	n.d.	n.d.	n.d.	982[(2)] 109[(3)]	0 0	0% 0%
Silver, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	15.6[(2)]	0	0%
Zinc, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	246[(2)(3)]	0	0%
Selenium, Total (ug/l)	10	3	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Mercury, Dissolved (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	1.4[(2)]	0	0%
Mercury, Total (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	0.051[(3)]	b.d	-----
Atrazine, Total (ug/l)	0.05	13	2.01	0.16	0.07	16.2	330[(2)] 12[(3)]	0 1	0% 8%
Metolachlor (ug/l)	0.05	13	-----	n.d.	n.d.	2.64	390[(2)] 100[(3)]	0 0	0% 0%
Alachlor (ug/l)	0.05	13	-----	n.d.	n.d.	0.26	760[(2)] 76[(3)]	0 0	0% 0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.33. Summary of Water Quality Conditions Monitored in the Missouri River near Nebraska City, Nebraska (RM563) during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Stream Flow (cfs)	-----	13	36,592	35,000	27,300	47,400	-----	-----	-----
Water Temperature (°C)	0.1	14	20.6	21.0	6.1	29.2	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	14	7.9	7.7	5.8	11.2	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	14	89.6	89.3	67.3	100.5	-----	-----	-----
Specific Conductance (umho/cm)	1	14	736	742	631	803	-----	-----	-----
pH (S.U.)	0.1	14	-----	8.3	7.8	8.8	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	12	338.6	74.3	41.0	2,009.0	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	11	360	361	312	399	-----	-----	-----
Alkalinity, Total (mg/l)	7	13	160	169	104	199	-----	-----	-----
Ammonia, Total (mg/l)	0.01	13	-----	0.10	n.d.	0.51	≤ 3.0(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	13	1.0	0.6	0.1	4.5	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	13	0.96	0.84	0.11	2.00	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	13	0.52	0.23	0.11	2.90	-----	-----	-----
Suspended Solids, Total (mg/l)	4	13	356	110	57	1,952	-----	-----	-----
Total Organic Carbon (mg/l)	0.05	13	3.7	3.6	2.9	4.9	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	13	27	18	7	134	-----	-----	-----
Chloride (mg/l)	0.02	13	22	20	14	39	≤860	0	0%
Hardness, Total (mg/l)	0.4	2	253	253	233	272	-----	-----	-----
Calcium, Dissolved (mg/l)	0.1	3	59	58	53	66	-----	-----	-----
Magnesium, Dissolved (mg/l)	0.04	3	25	24	24	26	-----	-----	-----
Sodium, Dissolved (mg/l)	0.2	3	70	70	66	74	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	340(2) 16.7(3)	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	3	-----	n.d.	n.d.	n.d.	4.70(2) 0.45(3)	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	1,167(2) 152(3)	0 0	0% 0%
Copper, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	30.6(2) 18.9(3)	0 0	0% 0%
Lead, Dissolved (ug/l)	5	3	-----	n.d.	n.d.	n.d.	165.0(2) 6.4(3)	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	3	-----	n.d.	n.d.	n.d.	982(2) 109(3)	0 0	0% 0%
Silver, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	15.6(2)	0	0%
Zinc, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	246(2)(3)	0	0%
Selenium, Total (ug/l)	10	3	-----	n.d.	n.d.	n.d.	20(2) 5(3)	0 b.d.	0% -----
Mercury, Dissolved (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	1.4(2)	0	0%
Mercury, Total (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	0.051(3)	b.d	-----
Atrazine, Total (ug/l)	0.05	13	1.61	0.35	n.d.	13.2	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	13	-----	0.13	n.d.	1.79	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	13	-----	n.d.	n.d.	0.26	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** (1)Total ammonia criterion pH and temperature dependent.
(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix A.34. Summary of Water Quality Conditions Monitored in the Missouri River near Rulo, Nebraska (RM498) during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Stream Flow (cfs)	-----	13	36,454	34,000	27,000	49,600	-----	-----	-----
Water Temperature (°C)	0.1	14	21.3	21.4	6.5	29.7	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	14	7.9	7.9	6.2	11.5	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	14	91.2	91.2	81.2	105.2	-----	-----	-----
Specific Conductance (umho/cm)	1	14	731	729	666	788	-----	-----	-----
pH (S.U.)	0.1	14	-----	8.3	7.4	8.8	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	12	183.9	77.6	52.6	738.3	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	11	359	363	310	397	-----	-----	-----
Alkalinity, Total (mg/l)	7	13	165	173	105	197	-----	-----	-----
Ammonia, Total (mg/l)	0.01	13	-----	0.25	n.d.	0.64	≤ 3.0[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	13	0.7	0.6	0.4	1.4	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	13	1.03	0.85	0.06	2.20	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	13	0.33	0.27	0.11	0.85	-----	-----	-----
Suspended Solids, Total (mg/l)	4	13	208	135	60	576	-----	-----	-----
Total Organic Carbon (mg/l)	0.05	13	3.4	3.4	3.0	4.0	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	13	22	18	4	45	-----	-----	-----
Chloride (mg/l)	0.02	13	20	19	16	30	≤860	0	0%
Hardness, Total (mg/l)	0.4	2	254	254	236	271	-----	-----	-----
Calcium, Dissolved (mg/l)	0.1	3	57	54	53	63	-----	-----	-----
Magnesium, Dissolved (mg/l)	0.04	3	24	24	23	25	-----	-----	-----
Sodium, Dissolved (mg/l)	0.2	3	66	66	63	68	-----	-----	-----
Arsenic, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	340[(2)] 16.7[(3)]	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	3	-----	n.d.	n.d.	n.d.	4.70[(2)] 0.45[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	1,167[(2)] 152[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	30.6[(2)] 18.9[(3)]	0 0	0% 0%
Lead, Dissolved (ug/l)	5	3	-----	n.d.	n.d.	n.d.	165.0[(2)] 6.4[(3)]	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	3	-----	n.d.	n.d.	n.d.	982[(2)] 109[(3)]	0 0	0% 0%
Silver, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	15.6[(2)]	0	0%
Zinc, Dissolved (ug/l)	20	3	-----	n.d.	n.d.	n.d.	246[(2)(3)]	0	0%
Selenium, Total (ug/l)	10	3	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Mercury, Dissolved (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	1.4[(2)]	0	0%
Mercury, Total (ug/l)	0.2	3	-----	n.d.	n.d.	n.d.	0.051[(3)]	b.d	-----
Atrazine, Total (ug/l)	0.05	13	0.95	0.26	n.d.	4.11	330[(2)] 12[(3)]	0 0	0% 0%
Metolachlor (ug/l)	0.05	13	-----	0.10	n.d.	0.65	390[(2)] 100[(3)]	0 0	0% 0%
Alachlor (ug/l)	0.05	13	-----	n.d.	n.d.	0.11	760[(2)] 76[(3)]	0 0	0% 0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

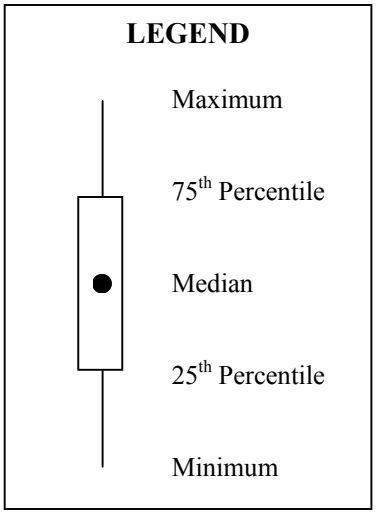
b.d. = WQS criterion below detection limit.

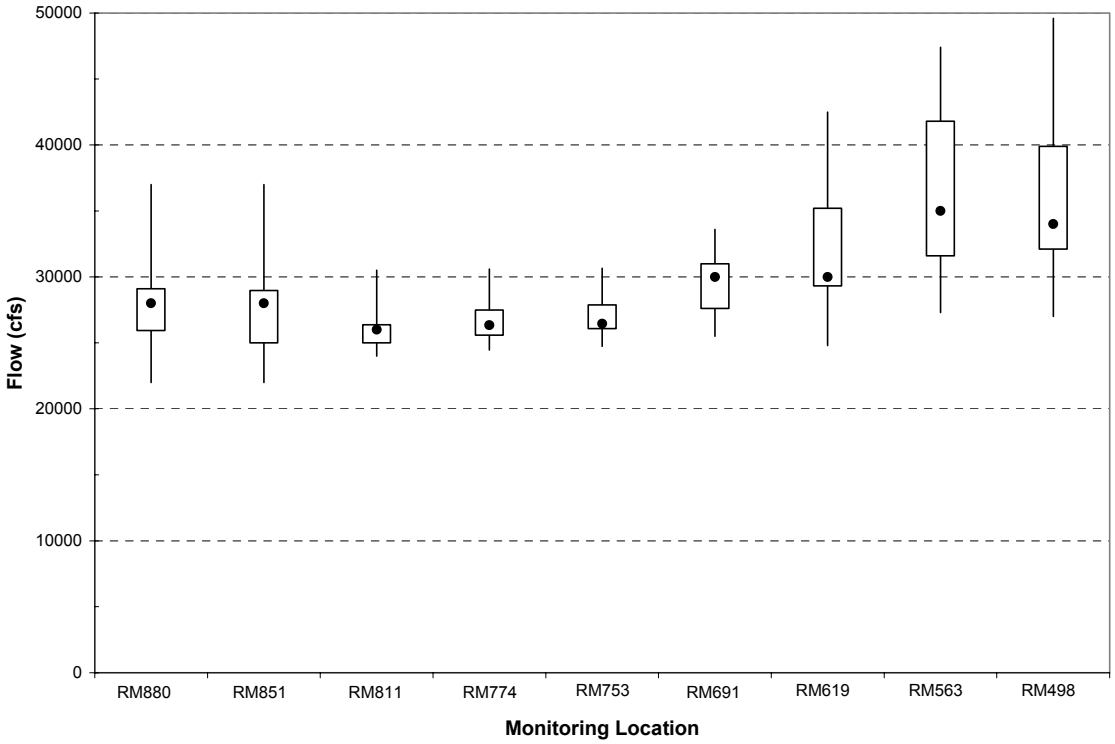
* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)

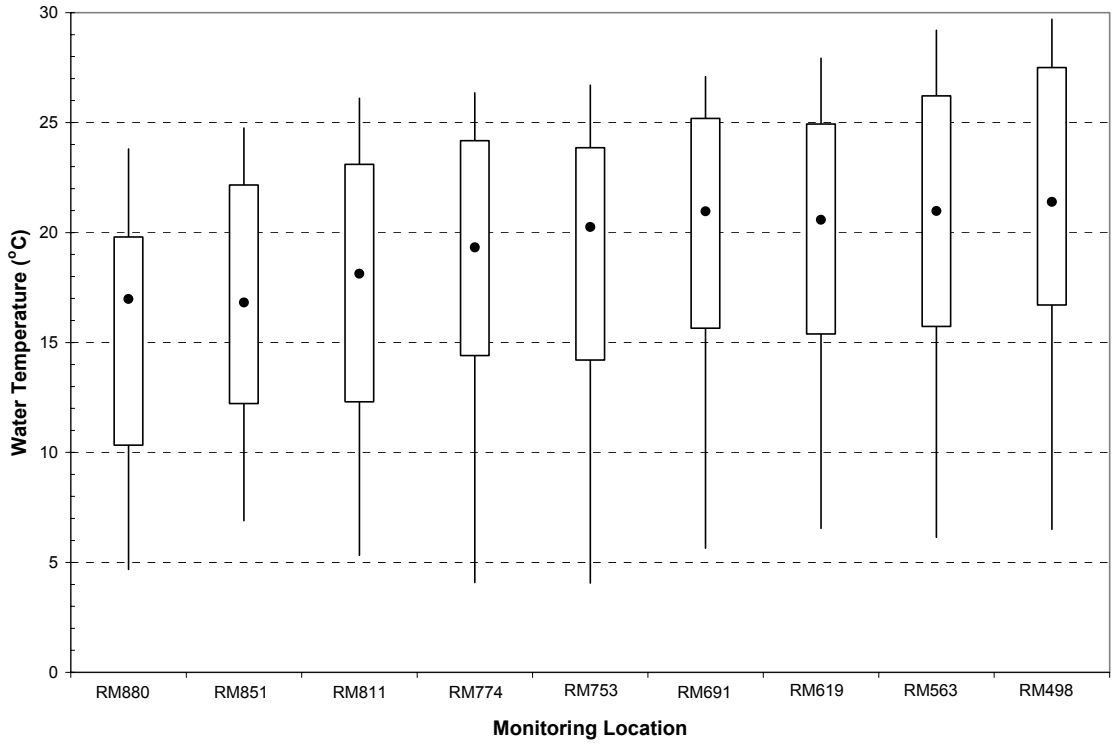
*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

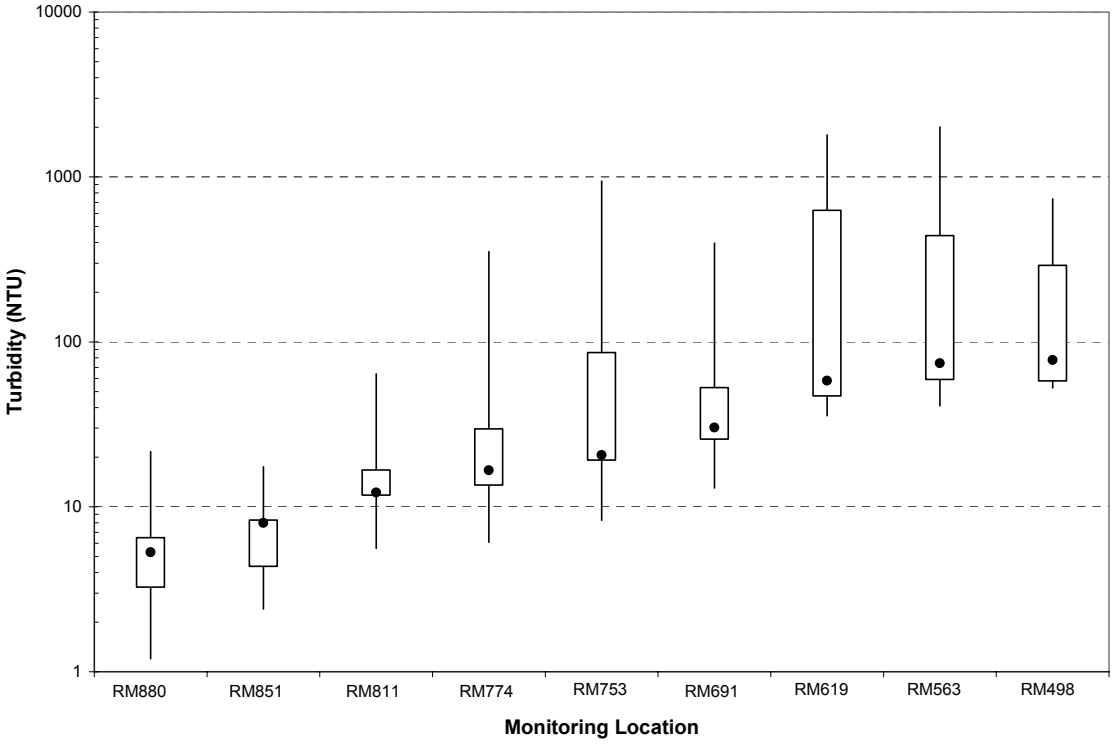
Appendix 35. Distribution plots (i.e., box plots) for selected parameters monitored in the Missouri River downstream of Fort Randall Dam during 2003. (See Appendices A.28 through A.34 for quantification of values and number of observations).



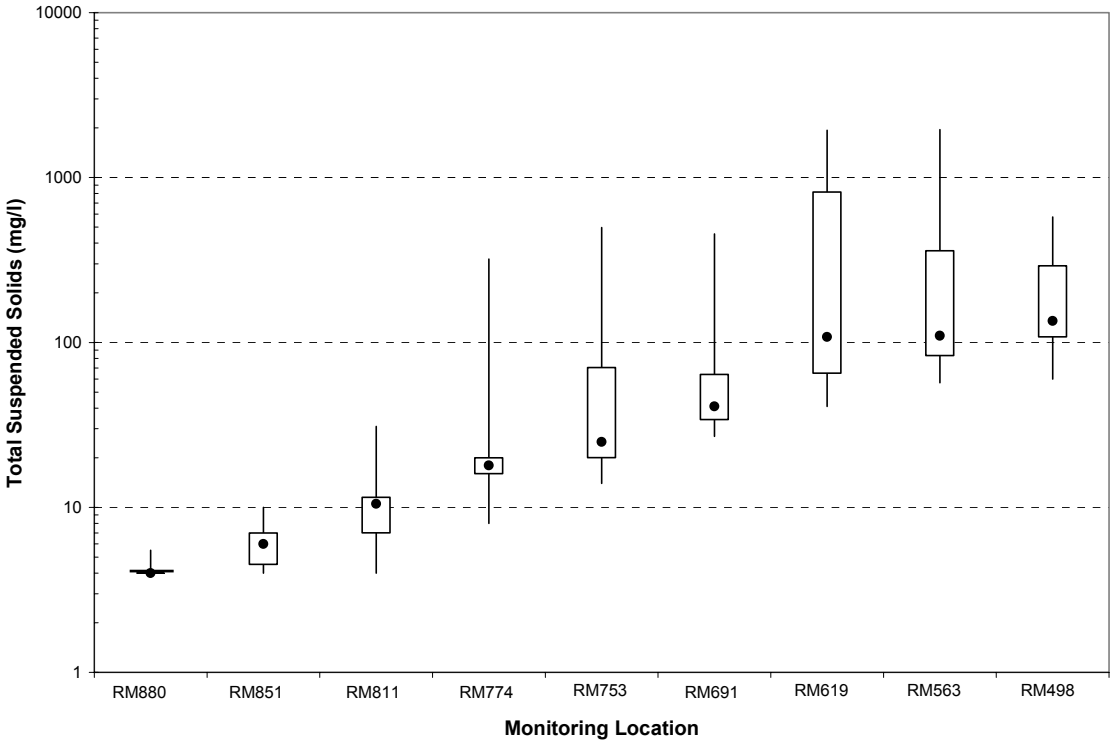


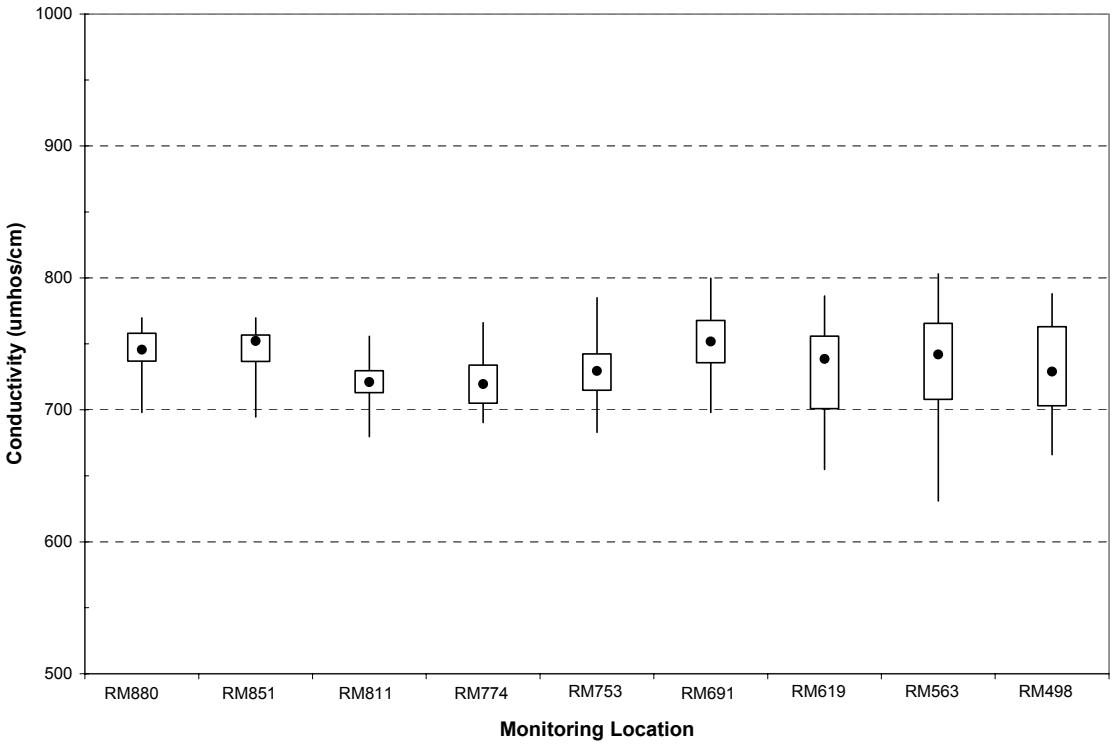
Appendix 35. (Continued).



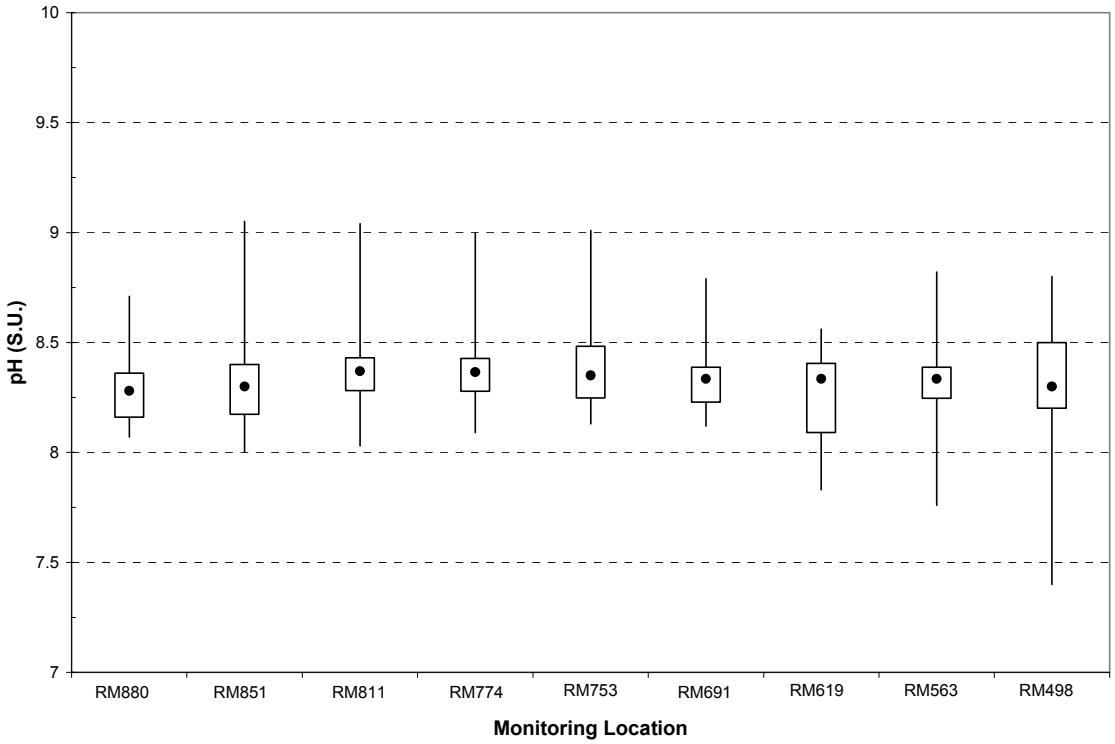


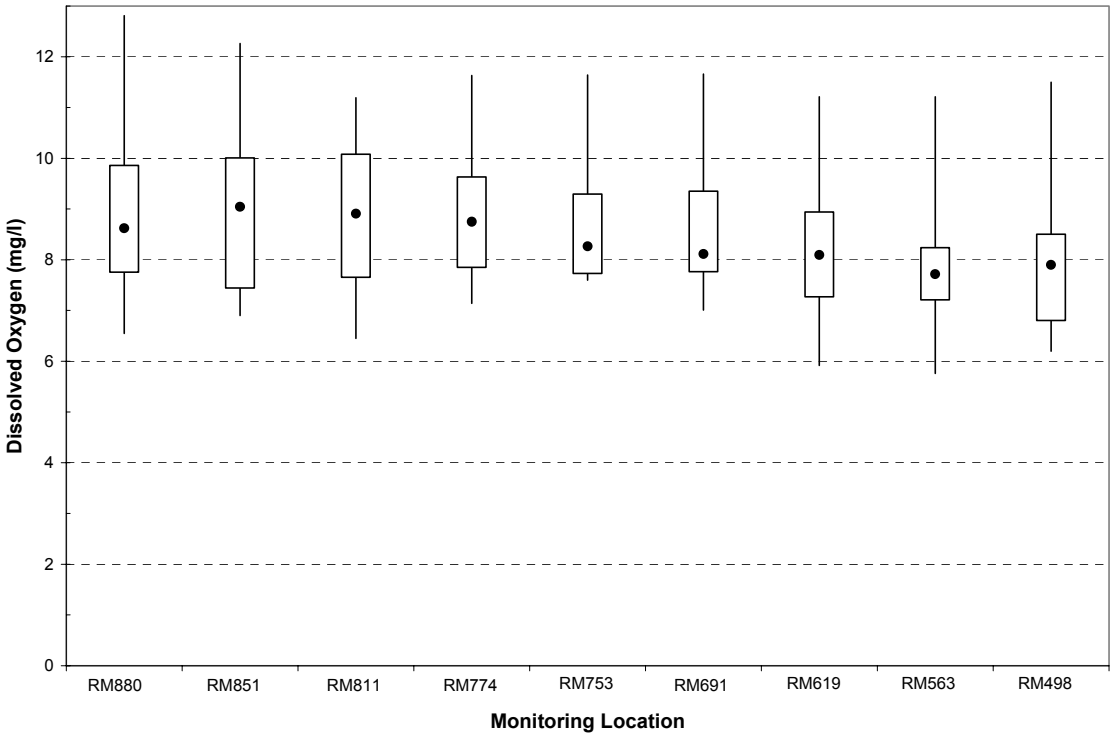
Appendix 35. (Continued).



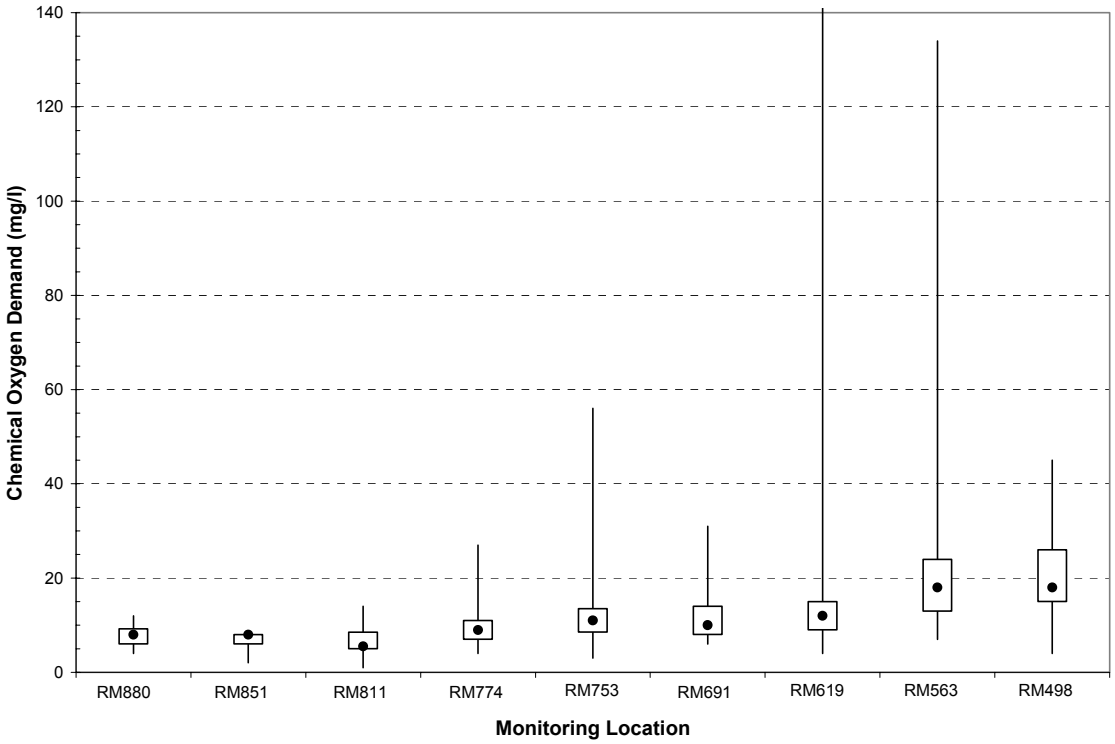


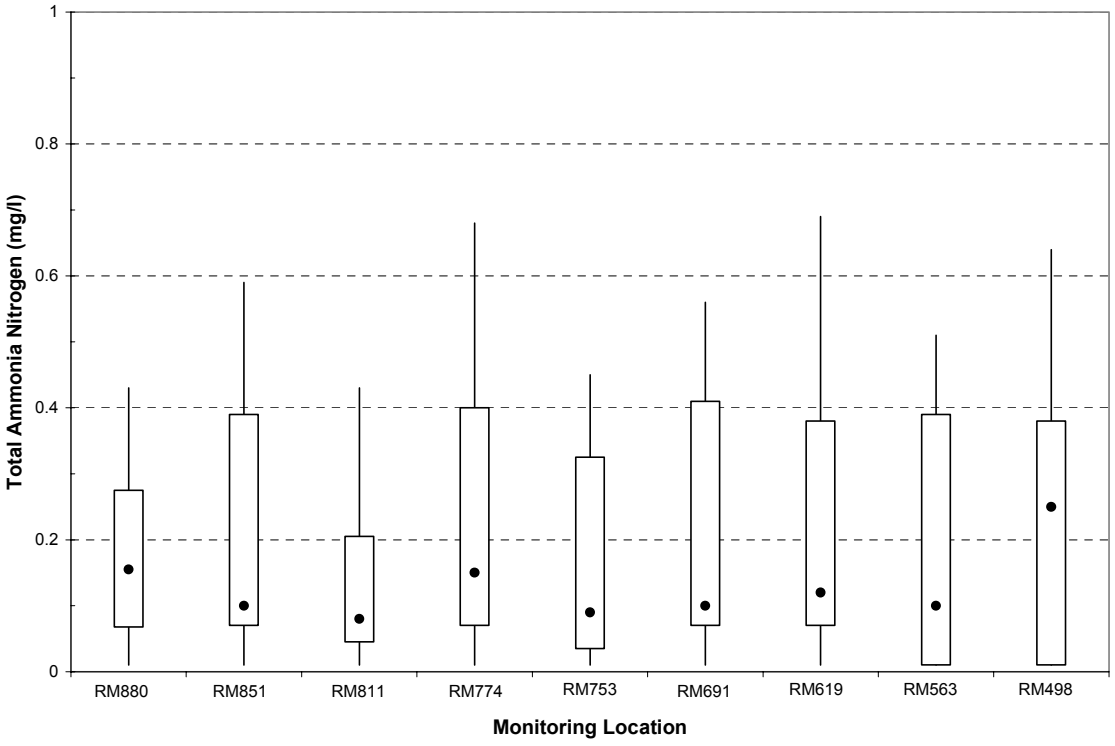
Appendix 35. (Continued).



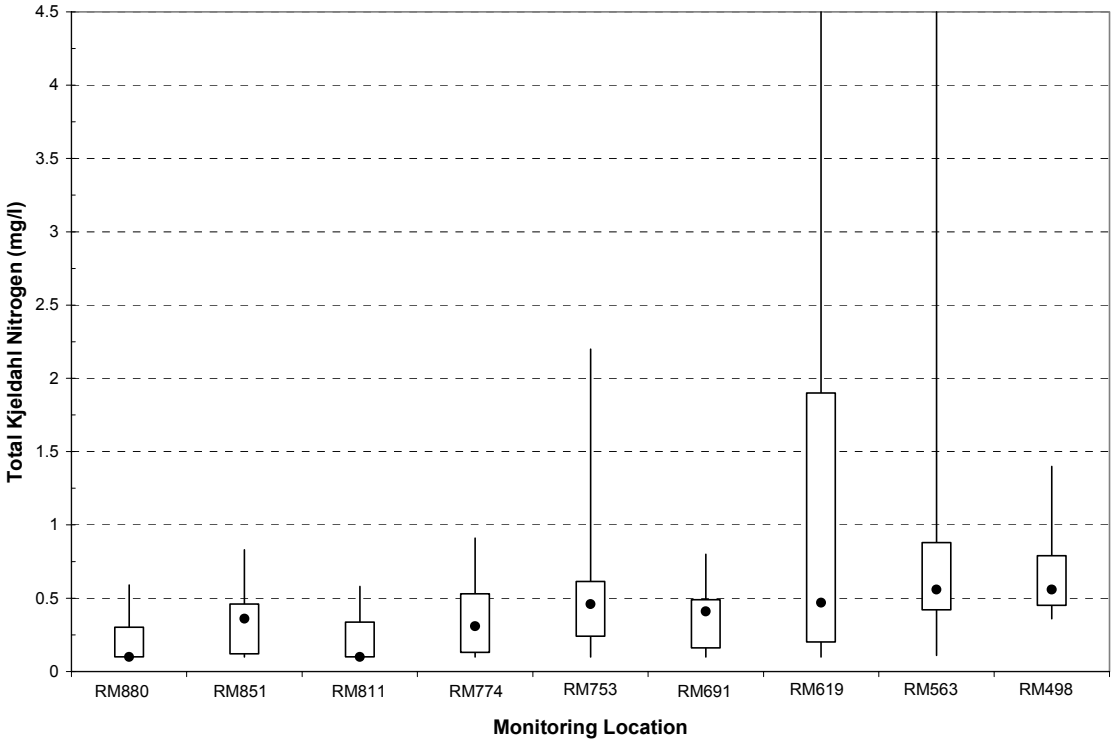


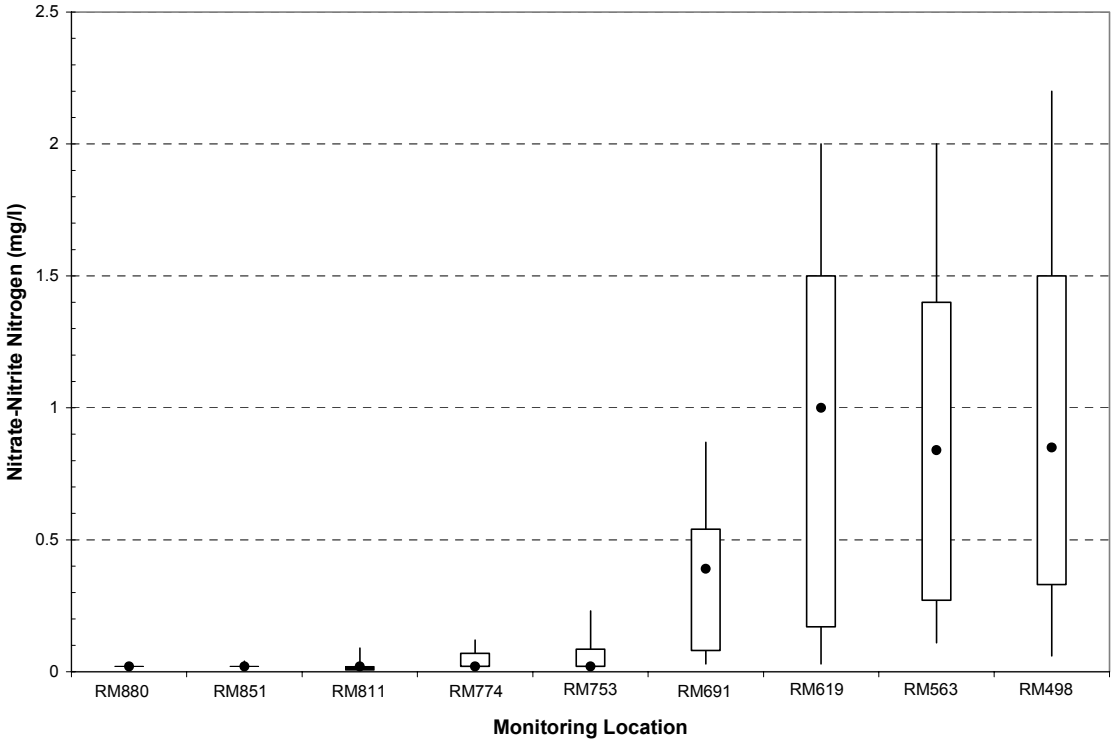
Appendix 35. (Continued).



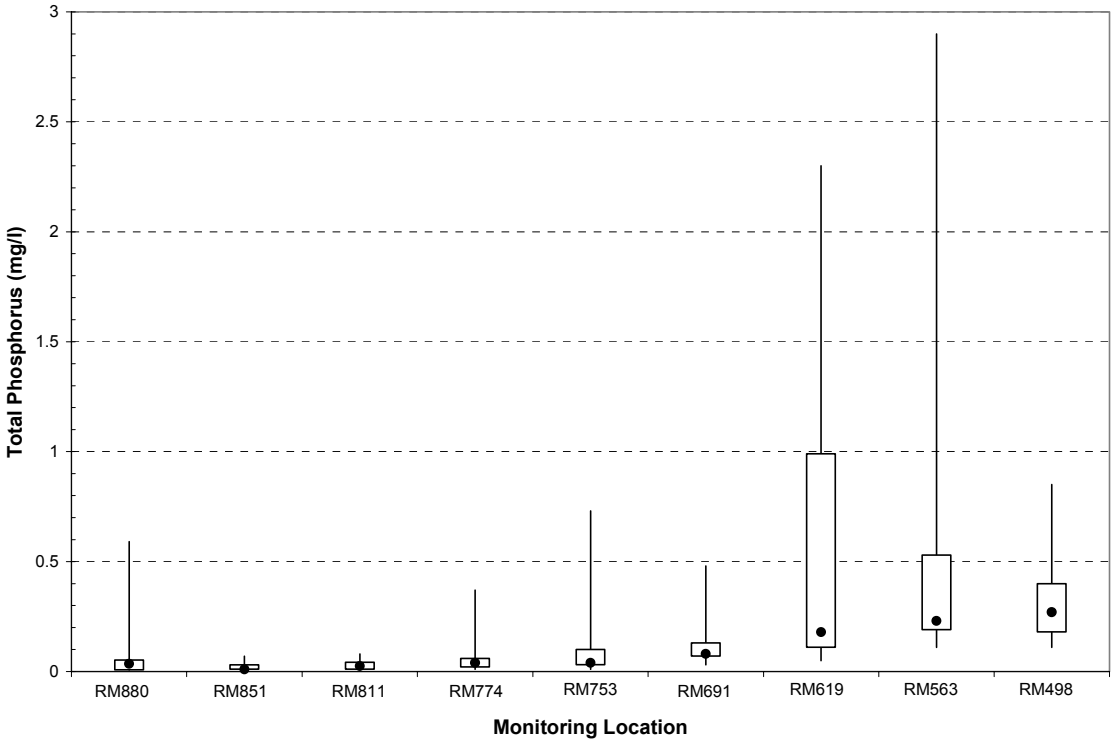


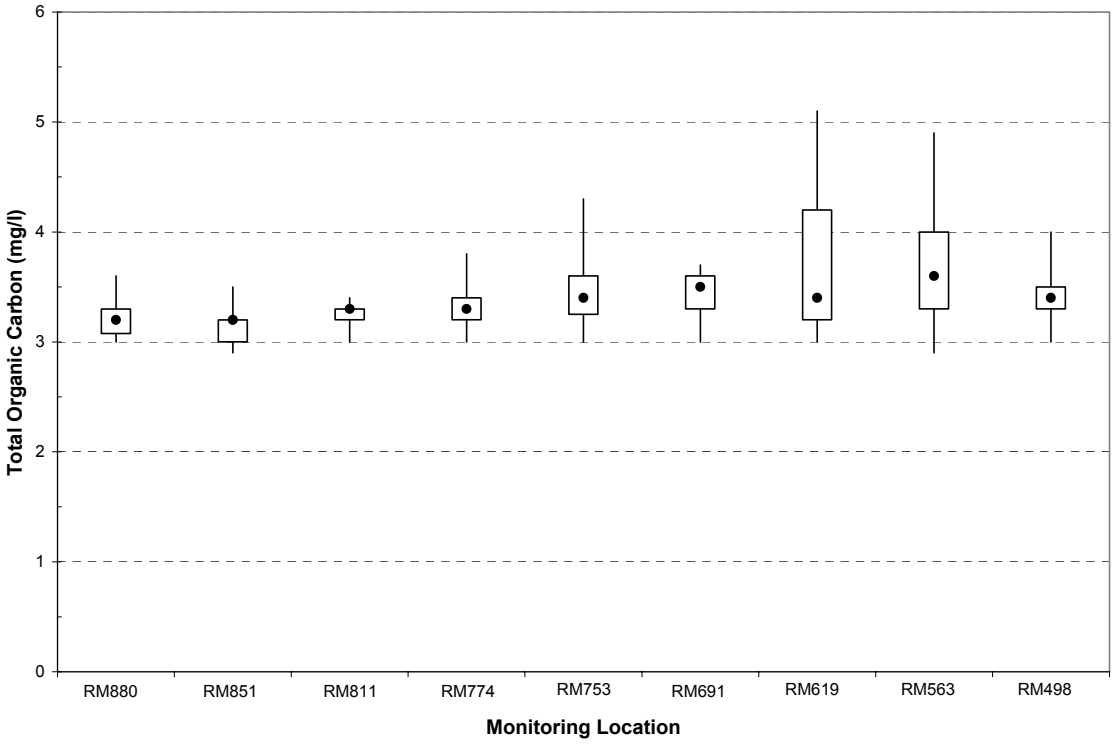
Appendix 35. (Continued).



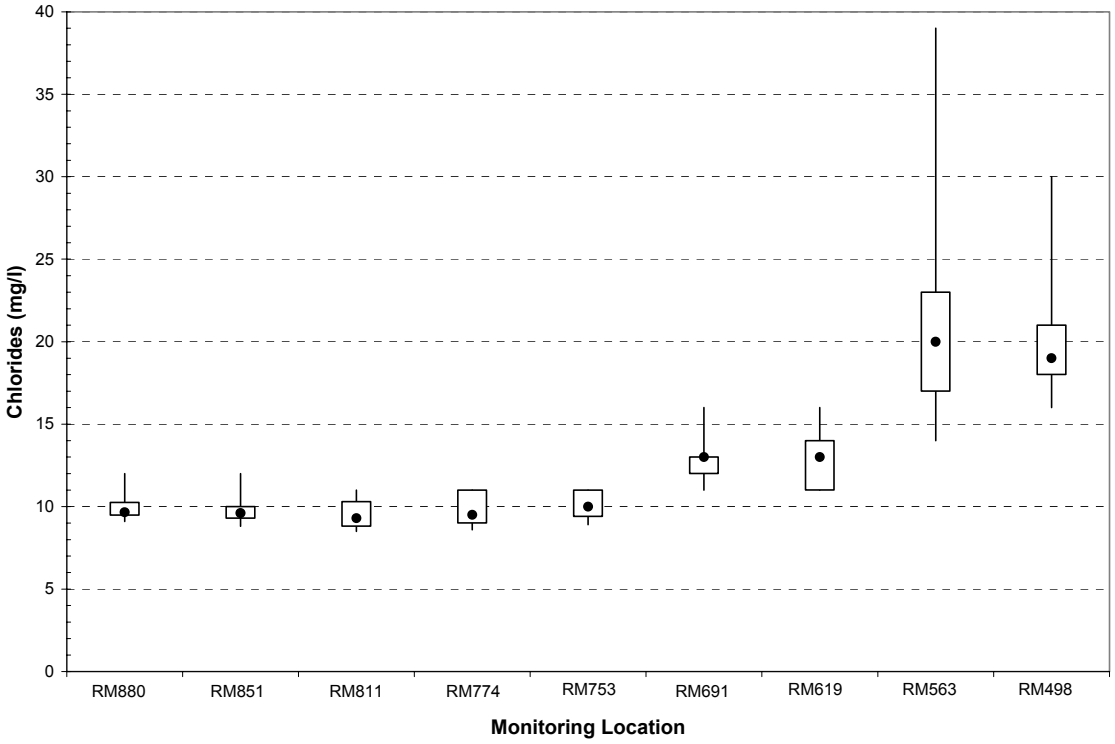


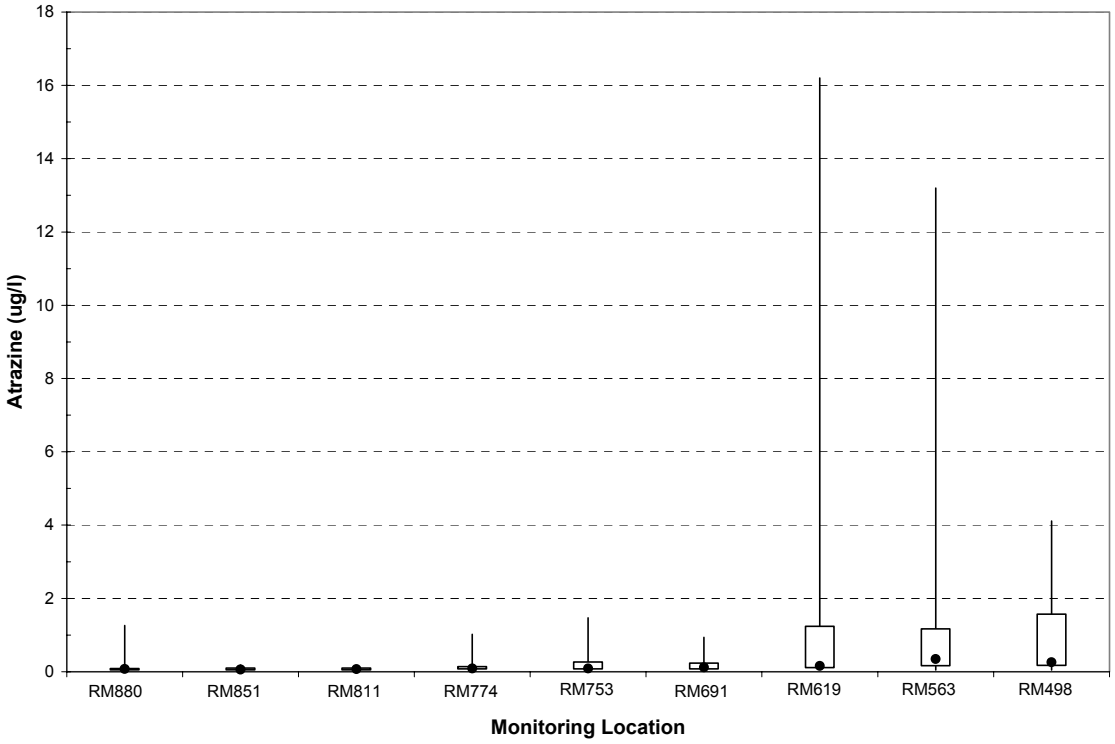
Appendix 35. (Continued).





Appendix 35. (Continued).





Appendix B.1. Summary of Water Quality Conditions Monitored in Bluestem Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1306.8	1306.9	1306.0	1307.5	-----	-----	-----
Water Temperature (°C)	0.1	77	19.4	19.4	14.9	26.7	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	77	6.7	7.2	4.2	8.7	≥ 5.0	3***	4%
Dissolved Oxygen (% Sat.)	0.1	77	77.7	79.9	46.1	97.4	-----	-----	-----
Specific Conductance (umho/cm)	1	77	307	303	280	339	-----	-----	-----
pH (S.U.)	0.1	77	-----	8.1	7.4	8.9	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	64	94	91	49	279	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	64	387	393	348	447	-----	-----	-----
Alkalinity, Total (mg/l)	7	10	100	109	46	132	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	-----	0.20	n.d.	0.82	≤ 1.46(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	0.5	0.4	0.1	1.2	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	0.70	n.d.	1.50	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.30	0.19	0.13	0.99	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	10	0.09	0.11	0.04	0.13	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	25	23	13	48	-----	-----	-----
Chlorophyll *a* (ug/l)	1	5	16	4	1	60	-----	-----	-----
Secchi Depth (in)	1	10	8	8	6	11	-----	-----	-----
Hardness, Total (mg/l)	0.4	6	140	144	127	150	-----	-----	-----
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	88(2) 30(3)	0 0	0% 0%
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	340(2) 16.7(3)	0 0	0% 0%
Beryllium, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	130(2) 5.3(3)	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	11.8(2) 1.1(3)	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	750(2) 98(3)	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	23(2) 15(3)	0 0	0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	99(2) 3.9(3)	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	1,880(2) 209(3)	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	1.4(2)	0	0%
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	0.051(3)	b.d	-----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20(2) 5(3)	0 b.d.	0% -----
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	6.1(2)	0	0%
Thallium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,400(2) 6.3(3)	0 0	0% 0%
Atrazine, Total (ug/l)	0.05	5	3.85	1.75	0.76	11.6	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	5	0.88	0.97	0.29	1.18	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	4	0.36	0.33	0.31	0.45	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

(1) Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.2. Summary of Water Quality Conditions Monitored in Branched Oak Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1279.3	1279.5	1278.5	1280.0	-----	-----	-----
Water Temperature (°C)	0.1	134	19.8	19.7	13.7	26.7	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	134	7.43	7.48	3.6	11.6	≥ 5.0	3***	2%
Dissolved Oxygen (% Sat.)	0.1	134	83.6	83.1	40.5	122.8	-----	-----	-----
Specific Conductance (umho/cm)	1	131	396	397	368	419	-----	-----	-----
pH (S.U.)	0.1	134	-----	8.2	7.8	9.0	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	81	33	30	21	59	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	81	380	364	350	427	-----	-----	-----
Alkalinity, Total (mg/l)	7	10	156	160	124	173	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	-----	0.20	n.d.	0.48	≤ 1.28(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	0.5	0.5	0.2	0.7	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	0.02	n.d.	0.14	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.14	0.07	n.d.	0.76	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	10	-----	n.d.	n.d.	0.02	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	17	17	9	27	-----	-----	-----
Chlorophyll *a* (ug/l)	1	3	18	17	16	20	-----	-----	-----
Secchi Depth (in)	1	15	17	17	9	24	-----	-----	-----
Hardness, Total (mg/l)	0.4	10	161	166	97	178	-----	-----	-----
Antimony, Dissolved (ug/l)	6	1	-----	n.d.	n.d.	n.d.	88(2) 30(3)	0 0	0% 0%
Arsenic, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	340(2) 16.7(3)	0 0	0% 0%
Beryllium, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	130(2) 5.3(3)	0 0	0% 0%
Cadmium, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	14.2(2) 1.3(3)	0 0	0% 0%
Chromium, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	839(2) 109(3)	0 0	0% 0%
Copper, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	27(2) 17(3)	0 0	0% 0%
Lead, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	118(2) 4.6(3)	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	1.4(2)	0	0%
Mercury, Total (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	0.051(3)	0	0%
Nickel, Dissolved (ug/l)	3	1	7.9	7.9	7.9	7.9	2,112(2) 235(3)	0 0	0% 0%
Selenium, Total (ug/l)	4	1	-----	n.d.	n.d.	n.d.	20(2) 5(3)	0 0	0% 0%
Silver, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	7.8(2)	0	0%
Thallium, Dissolved (ug/l)	6	1	-----	n.d.	n.d.	n.d.	1,400(2) 6.3(3)	0 0	0% 0%
Atrazine, Total (ug/l)	0.05	5	2.61	2.66	2.08	3.16	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	4	-----	0.09	n.d.	0.13	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	5	0.19	0.18	0.16	0.26	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

(1) Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.3. Summary of Water Quality Conditions Monitored in Conestoga Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1231.4	1231.1	130.5	1232.5	-----	-----	-----
Water Temperature (°C)	0.1	64	20.2	19.8	15.8	26.4	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	64	8.32	7.7	3.9	11.8	≥ 5.0	2***	3%
Dissolved Oxygen (% Sat.)	0.1	64	94.8	95.3	43.5	128.6	-----	-----	-----
Specific Conductance (umho/cm)	1	64	398	384	352	463	-----	-----	-----
pH (S.U.)	0.1	64	-----	8.7	7.9	9.2	≥6.5 & ≤9.0	10***	16%
Turbidity (NTUs)	0.1	38	34	14	5	96	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	38	349	344	330	385	-----	-----	-----
Alkalinity, Total (mg/l)	7	10	142	139	118	160	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	-----	0.13	n.d.	0.46	≤ 1.00[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	1.0	1.0	0.4	1.7	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	n.d.	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.16	0.12	0.07	0.32	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	10	-----	0.03	n.d.	0.17	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	21	17	6	49	-----	-----	-----
Chlorophyll *a* (ug/l)	1	4	49	50	10	86	-----	-----	-----
Secchi Depth (in)	1	10	25	23	9	55	-----	-----	-----
Hardness, Total (mg/l)	0.4	8	157	153	147	173	-----	-----	-----
Antimony, Dissolved (ug/l)	6	1	-----	n.d.	n.d.	n.d.	88[(2)] 30[(3)]	0 0	0% 0%
Arsenic, Dissolved (ug/l)	3	1	8.5	8.5	8.5	8.5	340[(2)] 16.7[(3)]	0 0	0% 0%
Beryllium, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	130[(2)] 5.3[(3)]	0 0	0% 0%
Cadmium, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	12.8[(2)] 1.2[(3)]	0 0	0% 0%
Chromium, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	823[(2)] 107[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	26[(2)] 17[(3)]	0 0	0% 0%
Lead, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	115[(2)] 4.5[(3)]	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	1.4[(2)]	0	0%
Mercury, Total (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	0.051[(3)]	0	0%
Nickel, Dissolved (ug/l)	3	1	7.9	7.9	7.9	7.9	2,070[(2)] 230[(3)]	0 0	0% 0%
Selenium, Total (ug/l)	4	1	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 0	0% 0%
Silver, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	7.5[(2)]	0	0%
Thallium, Dissolved (ug/l)	6	1	-----	n.d.	n.d.	n.d.	1,400[(2)] 6.3[(3)]	0 0	0% 0%
Atrazine, Total (ug/l)	0.05	5	4.17	4.45	2.7	5.9	330[(2)] 12[(3)]	0 0	0% 0%
Metolachlor (ug/l)	0.05	5	0.42	0.40	0.12	0.87	390[(2)] 100[(3)]	0 0	0% 0%
Alachlor (ug/l)	0.05	5	0.52	0.60	0.25	0.90	760[(2)] 76[(3)]	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

[(1)]Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.4. Summary of Water Quality Conditions Monitored in East Twin Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1340.4	1340.4	1339.5	1341.5	-----	-----	-----
Water Temperature (°C)	0.1	101	21.1	18.8	15.3	28.7	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	101	7.0	7.5	0.3	9.48	≥ 5.0	13***	13%
Dissolved Oxygen (% Sat.)	0.1	101	80.6	84.2	3.8	131.0	-----	-----	-----
Specific Conductance (umho/cm)	1	101	348	350	310	573	-----	-----	-----
pH (S.U.)	0.1	101	-----	8.2	7.1	8.8	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	42	56	42	22	237	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	42	355	370	84	411	-----	-----	-----
Alkalinity, Total (mg/l)	7	10	117	118	81	134	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	0.77	0.69	0.42	1.10	≤ 1.78(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	0.7	0.7	0.4	1.2	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	0.52	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.08	0.09	0.03	0.11	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	10	-----	n.d.	n.d.	0.02	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	25	16	9	75	-----	-----	-----
Chlorophyll *a* (ug/l)	1	3	35	37	11	56	-----	-----	-----
Secchi Depth (in)	1	10	22	22	8	36	-----	-----	-----
Hardness, Total (mg/l)	0.4	4	155	154	132	180	-----	-----	-----
Atrazine, Total (ug/l)	0.05	5	3.60	3.72	1.62	5.23	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	5	1.97	1.87	1.34	2.8	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	5	1.65	1.76	1.17	1.83	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

(1) Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.5. Summary of Water Quality Conditions Monitored in Ed Zorinsky Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1109.7	1109.7	1108.9	1110.7	-----	-----	-----
Water Temperature (°C)	0.1	150	21.8	22.7	14.4	28.6	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	150	6.6	7.0	0.35	14.9	≥ 5.0	32***	21%
Dissolved Oxygen (% Sat.)	0.1	150	77.7	85.6	4.0	174.9	-----	-----	-----
Specific Conductance (umho/cm)	1	150	466	465	422	555	-----	-----	-----
pH (S.U.)	0.1	150	-----	8.3	7.2	9.1	≥6.5 & ≤9.0	2	1%
Turbidity (NTUs)	0.1	67	10	6	1	65	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	68	362	377	149	429	-----	-----	-----
Alkalinity, Total (mg/l)	7	15	137	133	120	195	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	-----	0.49	n.d.	2.0	≤ 1.14(1)	1	20%
Kjeldahl N, Total (mg/l)	0.1	15	0.7	0.6	0.2	2.4	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	15	-----	n.d.	n.d.	0.09	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	15	0.11	0.07	0.02	0.49	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	15	-----	n.d.	n.d.	0.41	-----	-----	-----
Suspended Solids, Total (mg/l)	4	15	11	11	n.d.	33	-----	-----	-----
Chlorophyll *a* (ug/l)	1	8	29	30	4	58	-----	-----	-----
Secchi Depth (in)	1	16	39	26	13	132	-----	-----	-----
Hardness, Total (mg/l)	0.4	11	143	138	128	172	-----	-----	-----
Antimony, Dissolved (ug/l)	20	2	-----	n.d.	n.d.	n.d.	88(2) 30(3)	0 0	0% 0%
Arsenic, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	340(2) 16.7(3)	0 0	0% 0%
Beryllium, Dissolved (ug/l)	1	2	-----	n.d.	n.d.	n.d.	130(2) 5.3(3)	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	2	-----	3	n.d.	6	11.3(2) 1.2(3)	0 1	0% 50%
Chromium, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	763(2) 99(3)	0 0	0% 0%
Copper, Dissolved (ug/l)	20	2	-----	n.d.	n.d.	n.d.	24(2) 15(3)	0 0	0% 0%
Lead, Dissolved (ug/l)	5	2	-----	n.d.	n.d.	n.d.	102(2) 4.0(3)	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	2	-----	n.d.	n.d.	n.d.	1,913(2) 213(3)	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.2	2	-----	n.d.	n.d.	n.d.	1.4(2)	0	0%
Mercury, Total (ug/l)	0.2	2	-----	n.d.	n.d.	n.d.	0.051(3)	b.d	-----
Selenium, Total (ug/l)	10	2	-----	n.d.	n.d.	n.d.	20(2) 5(3)	0 b.d.	0% -----
Silver, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	6.4(2)	0	0%
Thallium, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	1,400(2) 6.3(3)	0 0	0% 0%
Atrazine, Total (ug/l)	0.05	10	2.75	2.89	1.00	4.21	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	10	0.26	0.17	0.10	0.90	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	10	-----	n.d.	n.d.	0.13	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

(1) Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.6. Summary of Water Quality Conditions Monitored in Glenn Cunningham Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1121.1	1121.1	1120.3	1122.0	-----	-----	-----
Water Temperature (°C)	0.1	100	20.8	19.8	14.9	27.5	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	100	6.3	7.2	0.3	9.2	≥ 5.0	22***	22%
Dissolved Oxygen (% Sat.)	0.1	100	71.2	77.3	3.9	118.4	-----	-----	-----
Specific Conductance (umho/cm)	1	100	359	357	299	423	-----	-----	-----
pH (S.U.)	0.1	100	-----	8.3	7.6	9.2	≥6.5 & ≤9.0	5	5%
Turbidity (NTUs)	0.1	59	28	22	15	75	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	59	366	364	342	391	-----	-----	-----
Alkalinity, Total (mg/l)	7	10	161	160	107	189	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	-----	0.52	n.d.	0.77	≤ 1.05(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	1.0	1.0	0.5	1.7	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	0.12	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.13	0.12	0.07	0.24	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	10	-----	n.d.	n.d.	0.02	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	16	16	n.d.	26	-----	-----	-----
Chlorophyll *a* (ug/l)	1	4	40	39	10	71	-----	-----	-----
Secchi Depth (in)	1	10	15	14	9	21	-----	-----	-----
Hardness, Total (mg/l)	0.4	6	182	194	148	204	-----	-----	-----
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	88(2) 30(3)	0 0	0% 0%
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	340(2) 16.7(3)	0 0	0% 0%
Beryllium, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	130(2) 5.3(3)	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	17.4(2) 1.4(3)	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	930(2) 121(3)	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	30(2) 19(3)	0 0	0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	138(2) 5.4(3)	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	2,349(2) 261(3)	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	1.4(2)	0	0%
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	0.051(3)	b.d	-----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20(2) 5(3)	0 b.d.	0% -----
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	9.7(2)	0	0%
Thallium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,400(2) 6.3(3)	0 0	0% 0%
Atrazine, Total (ug/l)	0.05	5	1.80	1.91	1.38	2.14	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	5	-----	0.06	n.d.	0.22	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	5	-----	n.d.	n.d.	0.08	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

(1) Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.7. Summary of Water Quality Conditions Monitored in Olive Creek Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1329.4	1329.5	1328.7	1330.0	-----	-----	-----
Water Temperature (°C)	0.1	37	19.4	19.0	15.6	24.7	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	37	8.9	9.1	4.0	11.1	≥ 5.0	1***	3%
Dissolved Oxygen (% Sat.)	0.1	37	100.6	112.3	42.0	123.3	-----	-----	-----
Specific Conductance (umho/cm)	1	37	263	263	200	315	-----	-----	-----
pH (S.U.)	0.1	37	-----	9.1	7.6	10.2	≥6.5 & ≤9.0	22	59%
Turbidity (NTUs)	0.1	22	52	34	22	109	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	23	376	376	324	426	-----	-----	-----
Alkalinity, Total (mg/l)	7	10	136	139	91	203	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	-----	0.25	n.d.	1.2	≤ 0.47[1]	1	20%
Kjeldahl N, Total (mg/l)	0.1	10	2.9	2.9	0.5	6.3	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	n.d.	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.29	0.28	0.10	0.51	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	10	-----	0.06	n.d.	0.11	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	35	33	20	56	-----	-----	-----
Chlorophyll *a* (ug/l)	1	5	72	63	11	170	-----	-----	-----
Secchi Depth (in)	1	9	13	9	6	22	-----	-----	-----
Hardness, Total (mg/l)	0.4	6	116	115	79	155	-----	-----	-----
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	88[2] 30[3]	0 0	0% 0%
Arsenic, Dissolved (ug/l)	10	1	22	22	22	22	340[2] 16.7[3]	0 1	0% 100%
Beryllium, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	130[2] 5.3[3]	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	8.9[2] 1.0[3]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	645[2] 64[3]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	20[2] 13[3]	0 0	0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	78[2] 3.1[3]	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	1,609[2] 179[3]	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	1.4[2]	0	0%
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	0.051[3]	b.d	-----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20[2] 5[3]	0 b.d.	0% -----
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	4.5[2]	0	0%
Thallium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,400[2] 6.3[3]	0 0	0% 0%
Atrazine, Total (ug/l)	0.05	5	7.78	9.75	1.59	13.30	330[2] 12[3]	0 1	0% 20%
Metolachlor (ug/l)	0.05	5	0.81	0.29	0.19	2.12	390[2] 100[3]	0 0	0% 0%
Alachlor (ug/l)	0.05	5	0.38	0.34	0.27	0.54	760[2] 76[3]	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Acetochlor (ug/l)	0.05	1	0.20	0.20	0.20	0.20	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

[1] Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

[2] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

[3] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.8. Summary of Water Quality Conditions Monitored in Pawnee Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1243.8	1243.8	1243.0	1244.5	-----	-----	-----
Water Temperature (°C)	0.1	102	19.6	19.8	15.2	27.5	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	102	8.1	8.0	2.1	10.7	≥ 5.0	4***	4%
Dissolved Oxygen (% Sat.)	0.1	102	91.6	90.4	26.7	139.8	-----	-----	-----
Specific Conductance (umho/cm)	1	102	348	366	303	382	-----	-----	-----
pH (S.U.)	0.1	102	-----	8.5	7.8	9.0	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	60	28.4	4.9	3.5	247.7	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	61	352	348	331	380	-----	-----	-----
Alkalinity, Total (mg/l)	7	8	141	146	103	171	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	-----	0.07	n.d.	0.41	≤ 1.32(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	0.6	0.5	0.2	1.3	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	n.d.	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.07	0.07	0.02	0.11	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	10	-----	n.d.	n.d.	0.02	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	18	13	n.d.	58	-----	-----	-----
Chlorophyll *a* (ug/l)	1	3	28	28	10	45	-----	-----	-----
Secchi Depth (in)	1	10	42	17	9	96	-----	-----	-----
Hardness, Total (mg/l)	0.4	8	141	138	123	165	-----	-----	-----
Antimony, Dissolved (ug/l)	6	1	-----	n.d.	n.d.	n.d.	88(2) 30(3)	0 0	0% 0%
Arsenic, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	340(2) 16.7(3)	0 0	0% 0%
Beryllium, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	130(2) 5.3(3)	0 0	0% 0%
Cadmium, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	11.3(2) 1.2(3)	0 0	0% 0%
Chromium, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	756(2) 98(3)	0 0	0% 0%
Copper, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	24(2) 15(3)	0 0	0% 0%
Lead, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	100(2) 3.9(3)	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	1.4(2)	0	0%
Mercury, Total (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	0.051(3)	0	0%
Nickel, Dissolved (ug/l)	3	1	7.9	7.9	7.9	7.9	1,896(2) 211(3)	0 0	0% 0%
Selenium, Total (ug/l)	4	1	5.1	5.1	5.1	5.1.	20(2) 5(3)	0 1	0% 100%
Silver, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	6.3(2)	0	0%
Thallium, Dissolved (ug/l)	6	1	-----	n.d.	n.d.	n.d.	1,400(2) 6.3(3)	0 0	0% 0%
Atrazine, Total (ug/l)	0.05	5	3.62	3.73	1.76	5.36	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	5	0.30	0.22	0.09	0.51	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	5	0.31	0.28	0.22	0.42	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

(1) Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.9. Summary of Water Quality Conditions Monitored in Standing Bear Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1103.8	1103.0	1101.9	1104.7	-----	-----	-----
Water Temperature (°C)	0.1	100	20.8	20.2	13.9	26.6	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	100	7.2	7.7	0.3	11.1	≥ 5.0	18***	18%
Dissolved Oxygen (% Sat.)	0.1	100	83.8	90.6	3.2	143.5	-----	-----	-----
Specific Conductance (umho/cm)	1	100	336	332	307	449	-----	-----	-----
pH (S.U.)	0.1	100	-----	8.2	7.1	8.8	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	63	21	19	9	46	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	63	354	358	122	427	-----	-----	-----
Alkalinity, Total (mg/l)	7	9	102	102	89	115	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	0.47	0.5	0.3	0.6	≤ 1.81[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	-----	0.6	n.d.	1.2	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	0.22	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.06	0.05	0.03	0.14	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	10	-----	n.d.	n.d.	0.02	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	17	15	7	46	-----	-----	-----
Chlorophyll *a* (ug/l)	1	4	37	38	7	65	-----	-----	-----
Secchi Depth (in)	1	10	24	22	13	40	-----	-----	-----
Hardness, Total (mg/l)	0.4	6	117	114	100	135	-----	-----	-----
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	88[(2)] 30[(3)]	0 0	0% 0%
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	340[(2)] 16.7[(3)]	0 0	0% 0%
Beryllium, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	130[(2)] 5.3[(3)]	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	8.8[(2)] 1.0[(3)]	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	647[(2)] 84[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	20[(2)] 13[(3)]	0 0	0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	79[(2)] 3.1[(3)]	0 0	0% 0%
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	1,615[(2)] 179[(3)]	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	1.4[(2)]	0	0%
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	0.051[(3)]	b.d	-----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 b.d.	0% -----
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	4.5[(2)]	0	0%
Thallium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,400[(2)] 6.3[(3)]	0 0	0% 0%
Atrazine, Total (ug/l)	0.05	5	0.72	0.72	0.46	1.0	330[(2)] 12[(3)]	0 0	0% 0%
Metolachlor (ug/l)	0.05	5	-----	n.d.	n.d.	0.1.	390[(2)] 100[(3)]	0 0	0% 0%
Alachlor (ug/l)	0.05	5	-----	n.d.	n.d.	0.06	760[(2)] 76[(3)]	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

[(1)]Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.10. Summary of Water Quality Conditions Monitored in Stagecoach Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1270.7	1270.8	1270.0	1271.0	-----	-----	-----
Water Temperature (°C)	0.1	71	20.4	20.0	15.6	30.5	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	71	7.4	7.6	1.5	13.0	≥ 5.0	14***	20%
Dissolved Oxygen (% Sat.)	0.1	71	84.5	86.2	16.6	177.3	-----	-----	-----
Specific Conductance (umho/cm)	1	71	393	345	332	488	-----	-----	-----
pH (S.U.)	0.1	71	-----	8.3	7.6	8.9	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	44.0	31.5	15.6	8.4	174.3	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	44	362	370	326	405	-----	-----	-----
Alkalinity, Total (mg/l)	7	9	167	156	139	194	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	-----	0.26	n.d.	0.45	≤ 1.61(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	0.5	0.5	n.d.	1.0	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	0.05	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.25	0.26	0.09	0.41	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	10	0.10	0.11	0.02	0.18	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	22	18	8	58	-----	-----	-----
Chlorophyll *a* (ug/l)	1	4	17	15	9	31	-----	-----	-----
Secchi Depth (in)	1	10	19	11	9	45	-----	-----	-----
Hardness, Total (mg/l)	0.4	8	160	151	132	208	-----	-----	-----
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	88(2) 30(3)	0 0	0% 0%
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	340(2) 16.7(3)	0 0	0% 0%
Beryllium, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	130(2) 5.3(3)	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	12.6(2) 1.3(3)	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	840(2) 109(3)	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	27(2) 17(3)	0 0	0% 0%
Lead, Dissolved (ug/l)	5	1	5	5	5	5	118(2) 4.6(3)	0 1	0% 100%
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	2,113(2) 235(3)	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	1.4(2)	0	0%
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	0.051(3)	b.d	-----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20(2) 5(3)	0 b.d.	0% -----
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	7.8(2)	0	0%
Thallium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,400(2) 6.3(3)	0 0	0% 0%
Atrazine, Total (ug/l)	0.05	5	3.36	2.85	1.77	5.51	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	5	0.52	0.44	0.23	1.00	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	5	0.23	0.24	0.20	0.25	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

(1) Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.11. Summary of Water Quality Conditions Monitored in Wagon Train Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1286.2	1286.0	1285.4	1287.8	-----	-----	-----
Water Temperature (°C)	0.1	76	19.7	19.2	14.9	30.8	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	76	7.8	8.4	0.36	14.5	≥ 5.0	14***	20%
Dissolved Oxygen (% Sat.)	0.1	76	88.6	95.4	4.5	164.4	-----	-----	-----
Specific Conductance (umho/cm)	1	76	334	330	310	392	-----	-----	-----
pH (S.U.)	0.1	76	-----	8.6	7.3	9.6	≥6.5 & ≤9.0	10	13%
Turbidity (NTUs)	0.1	46	14.9	6.9	0.9	37.5	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	46	358	358	244	400	-----	-----	-----
Alkalinity, Total (mg/l)	7	9	157	163	137	174	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	-----	0.25	n.d.	0.39	≤ 0.62(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	0.9	1.1	n.d.	1.6	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	n.d.	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.26	0.22	0.09	0.47	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	10	0.14	0.11	0.07	0.26	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	-----	13	n.d.	20	-----	-----	-----
Chlorophyll *a* (ug/l)	1	4	51	49	4	100	-----	-----	-----
Secchi Depth (in)	1	10	30	19	11	72	-----	-----	-----
Hardness, Total (mg/l)	0.4	8	133	135	117	143	-----	-----	-----
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	88(2) 30(3)	0 0	0% 0%
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	340(2) 16.7(3)	0 0	0% 0%
Beryllium, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	130(2) 5.3(3)	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	10.9(2) 1.1(3)	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	717(2) 93(3)	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	22(2) 14(3)	0 0	0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	92(2) 3.6(3)	0 1	0% 100%
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	1,796(2) 199(3)	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	1.4(2)	0	0%
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	0.051(3)	b.d	-----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20(2) 5(3)	0 b.d.	0% -----
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	5.6(2)	0	0%
Thallium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,400(2) 6.3(3)	0 0	0% 0%
Atrazine, Total (ug/l)	0.05	5	6.40	8.45	2.43	9.15	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	5	0.67	0.60	0.30	1.23	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	5	0.25	0.24	0.20	0.35	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Acetochlor (ug/l)	0.05	1	0.20	0.20	0.20	0.20	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

(1) Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.12. Summary of Water Quality Conditions Monitored in Wehrspann Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1091.0	1091.2	1089.5	1092.6	-----	-----	-----
Water Temperature (°C)	0.1	85	21.2	22.0	14.7	28.5	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	85	6.9	6.8	0.4	10.7	≥ 5.0	10***	12%
Dissolved Oxygen (% Sat.)	0.1	85	80.1	80.1	3.9	117.5	-----	-----	-----
Specific Conductance (umho/cm)	1	85	368	362	350	423	-----	-----	-----
pH (S.U.)	0.1	85	-----	8.6	7.6	8.9	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	26	10.6	8.3	3.8	25.9	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	26	363	356	307	408	-----	-----	-----
Alkalinity, Total (mg/l)	7	10	128	125	112	160	-----	-----	-----
Ammonia, Total (mg/l)	0.01	5	-----	0.21	n.d.	0.65	≤ 1.61(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	0.9	0.8	0.3	1.3	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	0.10	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.11	0.13	n.d.	0.19	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	10	-----	n.d.	n.d.	0.02	-----	-----	-----
Suspended Solids, Total (mg/l)	4	10	15	15	5	27	-----	-----	-----
Chlorophyll *a* (ug/l)	1	4	44	44	24	62	-----	-----	-----
Secchi Depth (in)	1	10	26	20	13	57	-----	-----	-----
Hardness, Total (mg/l)	0.4	6	116	116	104	128	-----	-----	-----
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	88(2) 30(3)	0 0	0% 0%
Arsenic, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	340(2) 16.7(3)	0 0	0% 0%
Beryllium, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	130(2) 5.3(3)	0 0	0% 0%
Cadmium, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	9.0(2) 1.0(3)	0 b.d.	0% -----
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	644(2) 84(3)	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	20(2) 13(3)	0 0	0% 0%
Lead, Dissolved (ug/l)	5	1	44	44	44	44	78(2) 3.1(3)	0 1	0% 100%
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	1,607(2) 178(3)	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	1.4(2)	0	0%
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	0.051(3)	b.d	-----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20(2) 5(3)	0 b.d.	0% -----
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	4.5(2)	0	0%
Thallium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1,400(2) 6.3(3)	0 0	0% 0%
Atrazine, Total (ug/l)	0.05	5	2.08	2.20	1.68	2.43	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	5	-----	0.07	n.d.	0.14	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	5	-----	n.d.	n.d.	0.08	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

(1) Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix B.13. Summary of Water Quality Conditions Monitored in West Twin Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	3	1340.4	1340.4	1340.0	1340.9	-----	-----	-----
Water Temperature (°C)	0.1	23	22.0	18.5	16.2	28.3	≤ 32	0	0%
Dissolved Oxygen (mg/l)	0.1	23	6.6	6.3	4.9	9.5	≥ 5.0	1***	4%
Dissolved Oxygen (% Sat.)	0.1	23	78.0	74.2	61.6	104.2	-----	-----	-----
Specific Conductance (umho/cm)	1	23	458	424	417	513	-----	-----	-----
pH (S.U.)	0.1	23	-----	8.3	7.7	8.7	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	13	110	144	43	204	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	13	398	419	349	429	-----	-----	-----
Alkalinity, Total (mg/l)	7	8	121	129	46	180	-----	-----	-----
Ammonia, Total (mg/l)	0.01	4	0.74	0.69	0.48	1.10	≤ 2.41(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	8	1.3	1.2	0.8	1.9	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	8	-----	n.d.	n.d.	0.86	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	8	0.23	0.24	0.16	0.29	-----	-----	-----
Orthophosphorus, Dissolved (ug/l)	0.01	8	-----	0.02	n.d.	0.12	-----	-----	-----
Suspended Solids, Total (mg/l)	4	8	57	46	16	126	-----	-----	-----
Chlorophyll *a* (ug/l)	1	4	26	29	7	40	-----	-----	-----
Secchi Depth (in)	1	8	8	9	4	12	-----	-----	-----
Hardness, Total (mg/l)	0.4	2	268	268	248	287	-----	-----	-----
Atrazine, Total (ug/l)	0.05	5	3.60	3.72	1.62	5.23	330(2) 12(3)	0 0	0% 0%
Metolachlor (ug/l)	0.05	5	1.97	1.87	1.34	2.8	390(2) 100(3)	0 0	0% 0%
Alachlor (ug/l)	0.05	5	1.65	1.76	1.17	1.83	760(2) 76(3)	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** Criteria apply only to the epilimnion if natural thermal stratification is present in the lake.

(1) Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.

(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based – listed criteria based on average hardness.)

(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based – listed criteria based on average hardness.)

*** The number of exceedences based on measurements at all depth and doesn't consider the occurrence of natural thermal stratification.

**** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix C.1. Summary of Water Quality Conditions Monitored in Bowman-Haley Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	2750.6	2750.7	2749.7	2751.3	-----	-----	-----
Water Temperature (°C)	0.1	177	17.4	18.9	11.0	25.8	≤ 29.4	0	0%
Dissolved Oxygen (mg/l)	0.1	176	7.3	7.1	2.4	11.5	≥ 5.0	24	14%
Dissolved Oxygen (% Sat.)	0.1	177	81.3	81.5	27.5	156.5	-----	-----	-----
Specific Conductance (umho/cm)	1	177	2,829	2,783	2,617	3,065	-----	-----	-----
pH (S.U.)	0.1	177	-----	8.7	8.0	8.9	≥7.0 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	29	17	16	13	33	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	29	373	373	372	374	-----	-----	-----
Secchi Depth (in.)	1	15	46	44	26	84	-----	-----	-----
Alkalinity, Total (mg/l)	7	8	368	370	337	396	-----	-----	-----
Ammonia, Total (mg/l)	0.01	8	0.20	0.19	n.d.	0.35	≤ 1.84(1)	0	0%
Kjeldahl N, Total (mg/l)	0.1	8	1.1	1.1	0.9	1.7	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	8	-----	0.02	n.d.	0.1	≤ 1.0(2)	0	0%
Hardness, Total (mg/l)	0.4	4	374	374	357	391	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	8	0.08	0.07	0.03	0.13	≤ 0.1(3)	1	13%
Orthophosphorus, Dissolved (mg/l)	0.01	8	-----	0.01	n.d.	0.04	≤ 0.02(2)	2	25%
Suspended Solids, Total (mg/l)	4	8	13	14	7	23	-----	0	0%
Chlorophyll *a* (ug/l)	1	3	28	8	5	71	-----	-----	-----
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	6(6)	b.d.	-----
Arsenic, Dissolved (ug/l)	10	1	3.1	3.1.	3.1	3.1	340(4) 150(5)	0 0	0% 0%
Beryllium, Dissolved (ug/l)	4	1	-----	n.d.	n.d.	n.d.	4(6)	0	0%
Cadmium, Dissolved (ug/l)	6	1	6	6	6	6	20.1 (4) 7.0 (5)	0 0	0% 0%
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	5,323(4) 254 (5)	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	49(4) 29(5) 1,000 (6)	0 0 0	0% 0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	439(4) 17(5)	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	1.7(4) 0.91(5) 0.05(6)	0 0 b.d.	0% 0% -----
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	1,435(4) 160(5)	0 0	0% 0%
Selenium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20(4) 5(5) 50(6)	0 b.d. 0	0% ----- 0%
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	39(4)	0	0%
Thallium, Dissolved, (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1.7(6)	b.d.	-----
Atrazine, Total (ug/l)	0.05	4	-----	n.d.	n.d.	0.06	-----	-----	-----
Metolachlor (ug/l)	0.05	4	-----	n.d.	n.d.	n.d.	-----	-----	-----
Alachlor (ug/l)	0.05	4	-----	n.d.	n.d.	n.d.	-----	-----	-----
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** (1) Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.
(2)Guidelines for use as goals in any lake improvement or maintenance program.
(3)Interim guideline limits.
(4) Acute criterion for aquatic life. (Note: If criterion is hardness dependent – number given is based on a hardness of 375 mg/l.)
(5) Chronic criterion for aquatic life. (Note: If criterion is hardness dependent – number given is based on a hardness of 375 mg/l.)
(6) Human health protection.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix C.2. Summary of Water Quality Conditions Monitored in Pipestone Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	5	1445.6	1445.2	1442.3	1449.6	-----	-----	-----
Water Temperature (°C)	0.1	141	19.1	19.0	12.6	25.1	≤ 29.4	0	0%
Dissolved Oxygen (mg/l)	0.1	141	6.0	6.8	0.2	9.6	≥ 5.0	35	25%
Dissolved Oxygen (% Sat.)	0.1	141	66.6	79.2	2.5	116.4	-----	-----	-----
Specific Conductance (umho/cm)	1	141	1,329	1,345	1,190	1,431	-----	-----	-----
pH (S.U.)	0.1	141	-----	8.3	8.1	8.8	≥7.0 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	80	121.3	10.5	0.9	418.0	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	81	265	325	8	408	-----	-----	-----
Secchi Depth (in.)	1	9	43	30	15	121	-----	-----	-----
Alkalinity, Total (mg/l)	7	9	304	302	273	343	-----	-----	-----
Ammonia, Total (mg/l)	0.01	10	0.40	0.36	n.d.	0.69	≤ 1.84[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	10	1.1	1.0	0.9	1.7	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	10	-----	n.d.	n.d.	0.05	≤ 1.0[(2)]	0	0%
Hardness, Total (mg/l)	0.4	4	495	494	461	532	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	10	0.44	0.39	0.32	0.67	≤ 0.1[(3)]	10	100%
Orthophosphorus, Dissolved (mg/l)	0.01	10	0.28	0.29	n.d.	0.51	≤ 0.02[(2)]	9	90%
Suspended Solids, Total (mg/l)	4	10	-----	7	n.d.	14	-----	0	0%
Chlorophyll *a* (ug/l)	1	5	21	10	4	45	-----	-----	-----
Antimony, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	6[(6)]	b.d.	-----
Arsenic, Dissolved (ug/l)	10	1	3.1	3.1.	3.1	3.1	340[(4)] 150[(5)]	0 0	0% 0%
Beryllium, Dissolved (ug/l)	4	1	-----	n.d.	n.d.	n.d.	4[(6)]	0	0%
Cadmium, Dissolved (ug/l)	6	1	6	6	6	6	27.8[(4)] 8.7[(5)]	0 0	0% 0%
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	6,737[(4)] 322[(5)]	0 0	0% 0%
Copper, Dissolved (ug/l)	20	1	-----	n.d.	n.d.	n.d.	64[(4)] 37[(5)] 1,000[(6)]	0 0 0	0% 0% 0%
Lead, Dissolved (ug/l)	5	1	-----	n.d.	n.d.	n.d.	633[(4)] 25[(5)]	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	1.7[(4)] 0.91[(5)] 0.05[(6)]	0 0 b.d.	0% 0% -----
Nickel, Dissolved (ug/l)	40	1	-----	n.d.	n.d.	n.d.	1,831[(4)] 204[(5)]	0 0	0% 0%
Selenium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Selenium, Total (ug/l)	10	1	-----	n.d.	n.d.	n.d.	20[(4)] 5[(5)] 50[(6)]	0 b.d. 0	0% ----- 0%
Silver, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	65[(4)]	0	0%
Thallium, Dissolved, (ug/l)	10	1	-----	n.d.	n.d.	n.d.	1.7[(6)]	b.d.	-----
Atrazine, Total (ug/l)	0.05	5	0.08	0.08	0.05	0.11	-----	-----	-----
Metolachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Alachlor (ug/l)	0.05	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)] Total ammonia criterion pH dependent. Listed criteria represents "worst case" conditions based on the highest pH measured in the lake.
[(2)]Guidelines for use as goals in any lake improvement or maintenance program.
[(3)]Interim guideline limits.
[(4)] Acute criterion for aquatic life. (Note: If criterion is hardness dependent – number given is based on a hardness of 375 mg/l.)
[(5)] Chronic criterion for aquatic life. (Note: If criterion is hardness dependent – number given is based on a hardness of 375 mg/l.)
[(6)] Human health protection.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix D.1. Summary of Water Quality Conditions Monitored in Cold Brook Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	4	3582.9	3582.9	3582.4	2583.6	-----	-----	-----
Water Temperature (°C)	0.1	145	20.3	19.6	11.3	24.5	≤ 18.3	112	77%
Dissolved Oxygen (mg/l)	0.1	145	8.7	8.4	0.6	12.1	≥ 6.0 ≥ 7.0	4 11	3% 8%
Dissolved Oxygen (% Sat.)	0.1	145	98.3	102	6.8	131	-----	-----	-----
Specific Conductance (umho/cm)	1	145	460	456	441	495	-----	-----	-----
pH (S.U.)	0.1	145	-----	8.3	7.3	8.5	≥6.6 & ≤8.6	0	0%
Turbidity (NTUs)	0.1	73	1.1	0.9	n.d.	4.7	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	73	353	328	143	441	-----	-----	-----
Secchi Depth (in.)	1	8	198	192	143	303	-----	-----	-----
Alkalinity, Total (mg/l)	7	8	158	157	141	169	-----	-----	-----
Ammonia, Total (mg/l)	0.01	8	0.35	0.31	n.d.	1.00	≤ 0.5[(1)]	1	13%
Kjeldahl N, Total (mg/l)	0.1	8	0.5	0.4	n.d.	1.3	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	8	-----	n.d.	n.d.	n.d.	≤ 10	0	0%
Hardness, Total (mg/l)	0.4	4	230	231	221	237	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	8	0.12	0.03	n.d.	0.73	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	8	-----	n.d.	n.d.	n.d.	-----	-----	-----
Suspended Solids, Total (mg/l)	4	8	-----	n.d.	n.d.	n.d.	≤ 53	0	0%
Chlorophyll *a* (ug/l)	1	4	2	2	1	4	-----	-----	-----
Antimony, Dissolved (ug/l)	6	1	-----	n.d.	n.d.	n.d.	14[(4)]	0	0%
Arsenic, Dissolved (ug/l)	3	1	3.1	3.1.	3.1	3.1	360[(2)] 190[(3)] 18[(4)]	0 0 0	0% 0% 0%
Beryllium, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Cadmium, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	9.6[(2)] 2.0[(3)]	0 0	0% 0%
Chromium, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	1,137[(2)] 367[(3)]	0 0	0% 0%
Copper, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	39.1[(2)] 24.2[(3)] 1,300[(4)]	0 0 0	0% 0% 0%
Lead, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	166.6[(2)] 6.5[(3)]	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	2.1[(2)] 0.012[(3)] 0.14[(4)]	0 b.d. 0	0% ----- 0%
Nickel, Dissolved (ug/l)	3	1	-----	n.d.	n.d.	n.d.	2,989[(2)] 332[(3)] 610[(4)]	0 0 0	0% 0% 0%
Selenium, Dissolved (ug/l)	4	1	-----	n.d.	n.d.	n.d.	20[(2)] 5[(3)]	0 0	0% 0%
Selenium, Total (ug/l)	4	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Silver, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	15.8[(2)]	0	0%
Thallium, Dissolved, (ug/l)	6	1	-----	n.d.	n.d.	n.d.	1.7[(4)]	b.d.	-----
Atrazine, Total (ug/l)	0.05	3	-----	0.07	n.d.	0.12	-----	-----	-----
Metolachlor (ug/l)	0.05	3	-----	n.d.	n.d.	0.07	-----	-----	-----
Alachlor (ug/l)	0.05	3	-----	n.d.	n.d.	0.08.	-----	-----	-----
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

b.d. = WQS criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note Several metal chronic criteria for aquatic life are hardness based.)
[(4)] Domestic drinking water supply.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

Appendix D.2. Summary of Water Quality Conditions Monitored in Cottonwood Springs Lake during 2003.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Lake Surface Elevation (ft)	-----	1	3862.1	3862.1	3862.1	3862.1	-----	-----	-----
Water Temperature (°C)	0.1	16	24.1	24.4	22.5	24.6	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	16	7.3	8.4	1.6	9.1	≥ 5.0	3	20%
Dissolved Oxygen (% Sat.)	0.1	16	90.9	104.3	19.3	112.9	-----	-----	-----
Specific Conductance (umho/cm)	1	16	1,794	1,796	1,780	1,809	-----	-----	-----
pH (S.U.)	0.1	16	------	8.9	7.4	8.9	≥6.5 & ≤9.0	0	0%
Secchi Depth (in.)	1	1	276	276	276	276	-----	-----	-----
Alkalinity, Total (mg/l)	7	2	51	51	46	56	-----	-----	-----
Ammonia, Total (mg/l)	0.01	2	-----	n.d.	n.d.	n.d.	≤ 0.7[(1)]	0	0%
Kjeldahl N, Total (mg/l)	0.1	2	-----	n.d.	n.d.	n.d.	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	2	-----	n.d.	n.d.	n.d.	≤ 10	0	0%
Phosphorus, Total (mg/l)	0.01	2	0.01	0.01	0.01	0.01	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	2	-----	n.d.	n.d.	n.d.	-----	-----	-----
Suspended Solids, Total (mg/l)	4	2	7	7	6	9	≤ 90	0	0%
Chlorophyll *a* (ug/l)	1	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Atrazine, Total (ug/l)	0.05	1	0.06	0.06	0.06	0.06	-----	-----	-----
Metolachlor (ug/l)	0.05	1	-----	n.d.	n.d.	0.11	-----	-----	-----
Alachlor (ug/l)	0.05	1	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The arithmetic mean was not calculated for pH because pH values are logarithmic.

** [(1)]Total ammonia criterion pH and temperature dependent.